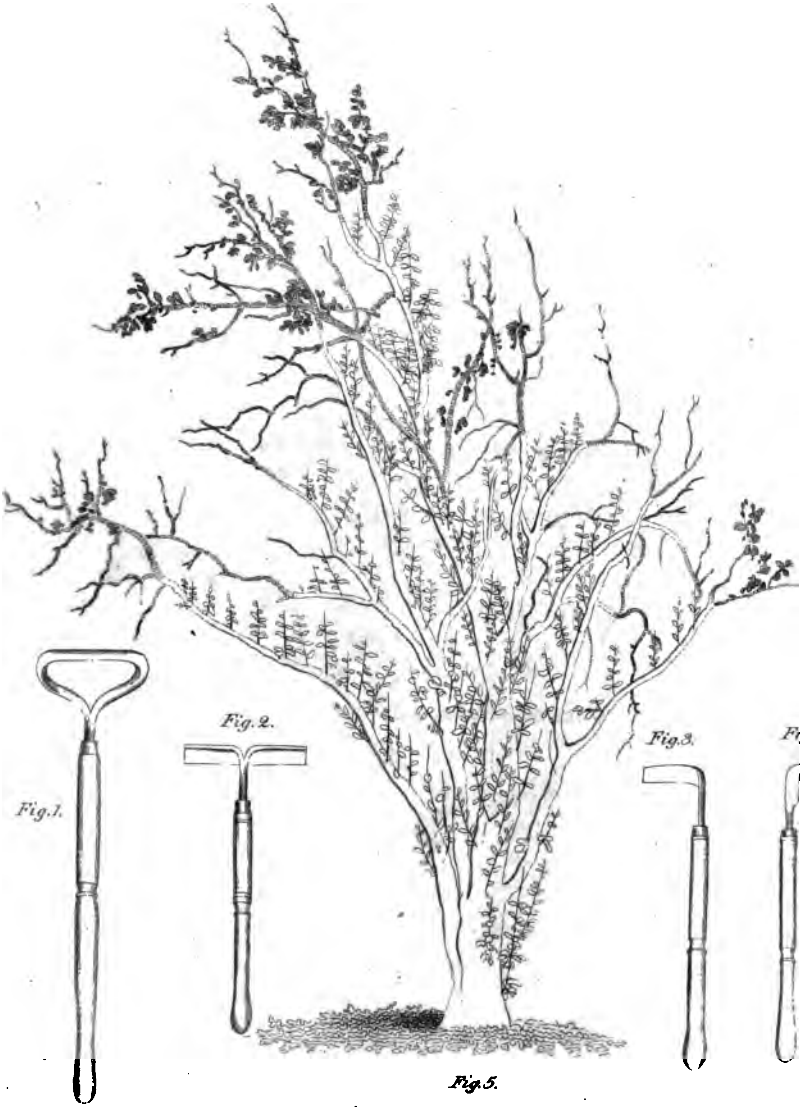
Fig.1.
Fig. 2.
Fig.3.
Fig.5.

A TREATISE ON THE PHYSIOLOGY AND PATHOLOGY OF TREES:

WITH

OBSERVATIONS ON THE BARRENNESS AND CANKER OF FRUIT TREES, THE MEANS OF PREVENTION AND CURE.

By P. LYON,

COMELY GARDEN, EDINBURGH;

WHERE THE INSTRUMENTS REPRESENTED IN THE ENGRAVING MAY BE HAD, CONSTRUCTED UNDER THE EYE AND DIRECTION OF THE AUTHOR.

Colere Deos, Colere Agros.
" By the sweat of thy brow shalt thou earn thy food."

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A

TREATISE, &c.

THE study of Nature, in every department of her works, has always been esteemed the most pleasant and entertaining of all studies. That part we are about to treat of, VEGETABLE PHYSIOLOGY, is both entertaining and useful, the health and existence of man depending solely upon those of vegetables, which can only be acquired and preserved by a knowledge of their nature and manner of growth.

As utility is our chief object, I wish to render this subject intelligible to every person, that it may become universally known.

When I first published my observations on fruit-trees, I had not read one page of any book on the subject, nor studied under any gardener or botanist whatever.—Since that I have, for various reasons, been induced to consult different authors; but I may say, with Mr Forsyth, that I soon found myself more bewildered than instructed: but he very prudently gave up the task; and had he not done so, he would have soon found himself in a maze from which he never could have extricated himself.

I found nothing but a few isolated facts—some imaginary ideas, and aerial flights of fancy, seemingly, and sometimes avowedly, for the purpose of amusement.

I have found no principles laid down; so that all the facts and observations stand like ghosts or apparitions, the inexplicable phenomena of nature, from which no general rules are drawn.

I have found nothing which could be called the *Physiology of Vegetables*.

It is true I found long catalogues of names, Greek and Latin, classes, orders, genera and species, &c. (but I could no more reckon that the physiology of vegetables, than the ranking of dogs into hounds, harriers, terriers, &c. the physiology of animals;) and I found I could learn no more of vegetable physiology *from it*, than of military tactics, *from knowing* that an army is ranked into generals, captains, serjeants, and drummers. We, therefore, consider it necessary to lay down a few principles or laws of nature taken from observation, which ought to be kept constantly in view.

1*st*, There is, in nature, a living principle, or something which gives life and nourishment to all vegetables.

2*d*, This principle or matter is found existing in all animal and vegetable bodies, and has commonly been known by the name of manure.

3*d*, These bodies do not part with this principle or matter, to enter into, or form new bodies, till their organization is completely dissolved.

4th, This matter is formed into new bodies by the influence of the atmosphere. The soil is to be considered only as a nidus.

5th, Nature has given to every vegetable the power of propagating its species. This power is exerted in many different ways, and forms a beautiful variety in the works of creation.

6th, Nature has given to every individual vegetable, a principle of self-preservation for the preservation of the species. This principle appears in many different modes, and presents a delightful field to the eye of the philosopher.

7th, This principle is in an inverse ratio to the powers of propagation.

8th, Every vegetable derives its existence from both earth and atmosphere, and consequently cannot live if completely deprived of either; hence it follows that

9th, The health of every vegetable depends upon a certain proportion between what it draws from the earth, and what it receives from the atmosphere.

10*th*, The organs by which the vegetable draws its nourishment from the earth, are the capillary roots. The organs by which it receives support from the atmosphere, are the buds, leaves, &c.

11*th*, By the principle of self-preservation, every vegetable will preserve life, if it has the requisite organs in health, and the means of subsistence within its reach. This principle, in many vegetables, goes a great deal farther; for when they are deprived of these organs, new ones are produced.

12*th*, As the health of a tree depends on a certain proportion between what it draws from the earth, and what it receives from the atmosphere, it follows

13*th*, That it must depend on the proportion of the respective organs, and also on that of the soil and climate; that is to say, as the capillary roots and soil (taken together) are to the branches and climate (taken together), so will the health of the tree, which will always be in an inverse ratio.

Example. If the capillary roots are numerous, and the soil rich and open, while the branches are few, and the climate cold, the tree will be proportionally unhealthy.

14*th*, The production of fruit requires a greater balance in favour of the atmosphere than the production of wood. This is observed from the effects of peeling, annular barking, transplanting or breaking off the capillary roots, and warm climates. What this difference may be, can only be ascertained from experience: but it will be greater in some species and varieties than in others.

15*th*, Any part of a tree is disposed to grow to roots or branches according as it is circumstanced. Thus, if a part of a root is exposed to the atmosphere, while another part of it is drawing nourishment from the earth, that part exposed to the atmosphere will grow to branches; and, *vice versa*, if a part of a branch is put into the earth, while another part of it is deriving support from the atmosphere, that part put into the earth will grow to roots.

16*th*, When a young tree is propagated from

an old one, if it has capillary roots, and put into the earth, it will grow and become a tree. This is called *planting*.

17*th*, When a part without roots is detached from a tree, it will not grow though put into the earth, (though this is a general rule, there are many exceptions, 11*th*); but if it is put upon another which has capillary roots, and their similar organs so fitted together that it can draw nourishment from the earth through the other, the two will unite and become a new tree. This is called *grafting*, and is only a species of planting; the graft, or *scion*, from the principle of self-preservation, to preserve life, requiring only to be put into such a situation that it can draw sustenance from the earth, and the stock or root support from the atmosphere.

The history or origin of grafting, it seems, is not known.

Mr Forsyth says, "The principles or philo-
"sophy of grafting is somewhat obscure, and
"had not accident given the first hint, all our
"knowledge of nature would never have led
"us to it." We cannot agree with Mr For-

syth in this opinion: we conceive that there is nothing which a man, who had paid any attention to the physiology and structure of a tree, would have been more easily and naturally led to; and though the man's name who first practised it, may now be lost, we are of opinion, that he did so from fair reasoning.

It is not my intention to entertain my readers with matters of amusement; at the same time I do not pretend to communicate much knowledge on the vegetable system; I only *attempt* to shew how knowledge may be obtained, to point out the road that may lead to something useful, to simplify this science, and to divest it of all that anatomical and microscopical imaginary lumber with which it has been loaded, and which, from the simple organization of the vegetable, it cannot admit of; which no doubt has deterred many one from the study, who might have made great progress in it; to guard the unwary traveller from falling into wrong paths from which it will be difficult to recall his steps.

For this purpose he must lay aside prejudice, nor believe all he hears or reads without con-

sulting his own judgment; nor attempt to discover by his own works, dissection, &c. what he should discover by the works of nature; and when any new phenomenon occurs, not to satisfy himself with the first apparent cause; for example, not to imagine that the east wind brings vermin from a foreign country, because vermin prevail most in those seasons east winds prevail.

. . . .

If I had believed in this, I never would have taken the method of destroying the vermin I have done. I would have thought of some scheme as wild and extravagant as the notion itself;—perhaps intercepting them in their passage, sending to combat them in their own country, or driving them home again, by offending their olfactory nerves and other feelings, with the smell and smoke of some burning substance.

We would earnestly request every person to make certain of the fact, by careful observation and repeated experiment, before he form a theory; he may then form what theory he pleases; if wrong, it cannot affect the fact; if right, it will lead to further discovery.

The husbandman is advised not to waste his time in chacing butterflies to dissect them, like our modern philosophers, nor in endless chemical pursuits to discover the soul of vegetables: he knows where it is to be found; let him study how to preserve it, and how it is to be best applied for the use of man.

As I have declared it to be my intention to point out the road that may lead to something useful, I cannot avoid making a few observations relating to agriculture (as connected with horticulture), which we consider an object of the first importance, and which has very justly been esteemed the strength of a nation; it is the blessings of peace, and the sinews of war.

It has been proposed as a subject of investigation, " the best means of increasing the " quantity of manure." This we consider a work of creation, and a vain pursuit for the creature to follow.

Whilst the chemical agriculturist, or agricultural chemist, is wasting his time and abusing his senses, leading thousands after him, to determine what chemical name he shall give

to manure, or that matter which is the food of vegetables, the sagacious husbandman is applying it for the use of his fellow-creature, and his own emolument.

The agricultural and horticultural chemist would employ his time to better purpose in analysing soils where certain kinds of trees and vegetables grow and flourish best, from which a table could be made out, that would enable any man about to plant an orchard, to chuse such trees as suited best his soil; or, if he had the choice of soil, to chuse that, suited to the kinds he wished to rear. We conceive the best and surest method to attain this end, would be to examine the soils where plants grow spontaneously. The same advantages would be derived to other vegetables. The great utility of such a table must be obvious to every one.

As increasing the quantity of manure is totally out of the question, and as it is of no consequence what name we give to that matter which gives nourishment to vegetables, I believe it to be a first principle, and can never be discovered in its simple state more than the

soul of man*; that it can neither be increased nor diminished by human power. It may change its place from one body to another, but itself cannot be changed. But knowing where it resides; that is, in all animal and vegetable substances, there are three things I wish to recommend to the attention of the husbandman and to that of the nation.

The first, to seek it out where it is lying hid or buried.

* Some think they have discovered the *pabulum vegetabile*, and call it carbon, hydrogen, oxygen, azot, &c. "others say, that no one principle affords the *pabulum* "of vegetable life, neither carbon, hydrogen, azot, nor "oxygen alone, but all taken together, in various states "and combinations;" consequently, the *pabulum* must be various. We confess our incapacity to understand any more of this *pabulum* by these terms, than we did by the old word, *manure*. We look upon seeking out the *pabulum vegetabile*, or soul of vegetables, not quite so rational as seeking for the philosophers' stone; but we have made a much greater discovery,—we have found that diamond is *pure* carbon, and that charcoal is *impure* carbon; we have, therefore, only to purify charcoal to get diamond, *more precious than gold*.

The second, to preserve it, when we have got it.

The third, to reduce these substances which contain it, to that state in which they readily part with it to nourish growing vegetables.

With regard to the first, we wish to mention uncultivated grounds full of the roots of vegetables, which, by cultivation and the assistance of lime, are reduced to a state of putrefaction, which makes them readily part with that matter which enters into other vegetables for their nourishment and growth.

We do not believe that there is any of this nutritive matter in lime itself; but that it promotes vegetation in two ways.

By its putrefactive quality reducing any animal or vegetable substance in the ground to that state by which the nutritive part can be taken up by other vegetables:

And, by its expanding quality, opening the soil, and allowing the growing vegetables to send forth their roots with greater ease to col-

lect nourishment. For it has been observed that grounds which have been limed and fully cultivated, are not ameliorated by a second liming.

I have the same opinion of burnt clay as of lime,—that it contains none of the vegetable food, but that it promotes vegetation by opening the soil. It is probable, too, that it may promote vegetation by producing a certain degree of heat on getting rain. I have made some experiments on this, but not sufficient to warrant a general conclusion. The temperature of the atmosphere was 48°, the earth 52°, the burnt clay 52°; on mixing it with a quantity of water it raised the thermometer to 58°. I repeated the experiment several times at different periods, and found that it raised the thermometer from 3 to 6 degrees. I did not, however, find the same effects when the temperature of the atmosphere and earth was greater than above stated: that it keeps the soil open, I am perfectly satisfied from experience.

And, in this respect, I have reason to think

that it will be preferable to lime by retaining this power longer.

The next thing we wish to take notice of on this head, is, many places where vast quantities of this vegetable matter are lying hid or buried; what is commonly called *vegetable mould.*

Very little advantage has been taken of this so far as I know. Almost the only use which I know has been made of it, is trenching, which raises new mould containing the vegetable food within reach of the growing vegetable roots, while all the matter below lies dormant.

Where grounds are mountainous or rocky, and cannot be cultivated, the vegetable matter may be extracted by planting them with forest trees, which send their roots into the crevices of the rocks, and draw the nutritive matter or manure to the trunk and branches, and so within the reach of man to make what use of he thinks proper; and it is believed that such grounds, in time, will reward the husbandman little worse than those that are capable of other modes of cultivation; for the trees continually shedding their leaves afford a constant source

of manure, while the wood becomes of great value for mechanical purposes, none of which need ever again be lost to the use of man.

As most vegetables, especially those which are most useful, do not require a deep mould, it certainly would be of advantage to the farmer, and a benefit to the country, to remove a part of this mould where it is too thick, and lay it on grounds where it is too thin; and we know that there are many places,—whole fields and large tracts of land,—where this fine mould is lying untouched since first it was formed.

We may observe here, that soils might often be improved at no great expence. For we have observed one field too much inclined to clay, and another, at small distance, too much inclined to sand, a part of which might be transposed, and both ameliorated.

It frequently happens, too, that the soil of a field is too much clay, while the sub-soil is sand, and *vice versa*; these being mixed, the same benefit would be obtained.

The second object I pointed out, to preserve

the manure when we have got it, is of the greatest importance.

The farmers are very attentive to this object; but all their efforts can avail but little, while almost the whole produce of the fields is carried to great towns, swept into the common sewers, and sent to the ocean.

A very strange notion has been entertained, that manufactories are of benefit to agriculture.

They may be of advantage to the farmer in disposing of his crop ; but it must be a loss to the ground, where so much of that matter, which is given by nature for a succession of crops, is *carried off and no return made.* For though a few acres about a great or manufacturing town are enriched, it is at the expence of *ten times* the number at a distance. Therefore, as great towns are numerous and daily increasing in population, the only remedy for preserving our manure, is saving the common sewers, which might easily be done by machinery. A steam engine could be erected for a few thousand pounds, capable of raising

every drop of the greatest common sewer in Great Britain, which could be carried in pipes under ground to any distance, *and be much less a nuisance than they are at present;* and where there is a natural declivity, there would be no occasion for an engine.

This is an object which I have long had in view, and had long ago mentioned it to some who certainly had much in their power. Whether I shall ever see it put in execution I know not; but I am persuaded that future generations will laugh as much at us for this neglect, as we do at our ancestors for throwing the dung of the streets, &c. &c. into the rivers, and with better reason, for it is the best part we send to the ocean.

It would be difficult to calculate the value of common sewers; but we conceive what goes out of every great town equal in value to what comes into it; for nothing is lost in nature.

The third object I pointed out,—reducing those substances which contain the vegetable nutriment to that state in which

they readily give it out for the purposes of vegetation. This is a subject so universally well known, that I need say very little on it. Every person the least acquainted with agriculture or horticulture, knows that they require to be reduced to a state of putrefaction; and they know how to promote putrefaction, and mix them with the soil. I have only to observe that air and moisture are necessary for reducing these substances to a state of putrefaction: this, however, requires a little regulation; for, if the moisture is too great, it will prevent the action of the air; and if too small, it will be evaporated and the matter dry. To allow the action of the air to have full effect, it is also necessary that too great a quantity of the materials should not be laid together at once, but to add, after the putrefaction is fairly begun, gradually to the heap, keeping it moderately moist. Animal substances and green vegetables have moisture enough in themselves, and do not require any additional, except where the process goes on so rapidly as to produce a very great degree of heat, dry up the substances, and threaten combustion.

All the writers on the vegetable physiology whom I have consulted, point out the analogy between it and the animal.

That a knowledge of the one may contribute to throw light on the other, there can be no doubt; but if the analogy is carried too far, it will have a contrary effect, and lead into obscurity and confusion, from which we will never be able to extricate ourselves. We conceive it a more natural and easy way, to begin instruction with the most simple, and proceed from that to the more complex and intricate. Had the vegetable system been studied with the same assiduity as the animal, more light would have been thrown on the animal from the vegetable, than what has been thrown on the vegetable from the animal. We look upon studying the animal system, to attain a knowledge of the vegetable, like learning arithmetic by beginning with algebra, or mathematics with conic sections.

This seems to have been the practice of those writers, who appear to have been medical men, and carried with them all their anatomical terms and physiological notions, right

or wrong, into the vegetable system. "*Cortical beds, cellular coverings, cellular textures, reticular textures, parenchematous membranes, proper vessels, lymphatic vessels, nerves, lungs, arteries, veins, placentas, umbilical chords,*" &c. &c. &c. &c. When all these are ranked up with *phlogiston, caloric, carbon and azote*, mercy on us! where are we? we can neither advance nor retreat. We are entangled in nets, and suffocated with phlogiston. Men of ordinary education and abilities, terrified to enter into a world of such learned words, as they would be into a world of spirits, give up the study, thinking it fit only for Rosicrucians and Illuminati. But, wonderful to tell! after having placed all these vessels in both wood and bark of a tree, they inform us that there is nothing like them to be found in either.

To avoid getting into this labyrinth, it is more necessary to shew the difference of the two systems, than to point out the analogy.

The animal and vegetable are so very different in their structure and physiology, that, though there is a general analogy, there are but few particular cases where any *rational*

comparison can be made. They are different in their formation, they are different in their manner of growth, and they are different in the manner they receive their nourishment.

All the parts of an animal are perfectly evolved at a very early period, and a complete animal formed, which cannot be divided and multiplied (into more). All the parts grow and increase in size by *extension*, till the age of maturity, after which they decline, without a possibility of being revived, or any substitution being made.

Trees do not grow and increase in size by extension; but by *addition* or accretion; every part,—trunk, roots, and branches receiving annually an additional shoot, joined to the former by a kind of cicatrix, which increases them in length; and an additional coat or layer, which increases them in thickness. New members, roots, and branches are added to the tree, during the whole time of its growth, till it arrive at maturity; and even after that, at least, what has commonly been called maturity, they can be revived and new ones produced.

A tree can be divided and multiplied into any number.

In the animal, the substances formed in different parts of the body are either thrown out by excretory organs, or returned into the system; in the vegetable, the substances formed in different parts are neither thrown out, nor returned into the system, but remain in these parts till they are taken off by the hand of man, or the part destroyed by nature. The animal receives its nourishment from a mass thrown into a common reservoir. The vegetable draws its nourishment through many minute channels, and they depend on different parts of the atmosphere for their existence. Though it must be admitted that vegetables have sensation, it is different from that of animals, and is merely a capacity of being affected by external agents; but the animal has a voluntary power in itself. We cannot explain this better than by the comparison between day and night animals: the action of light on the eye of the day animal gradually contracts the pupil, but the night animal contracts or dilates it suddenly at pleasure. At the same time, as every person has paid

more or less attention to the animal economy, but few to the vegetable, it will be necessary occasionally to have recourse to analogy by way of elucidation. To understand the physiology of a tree, it is necessary to know something of its structure; and as few have studied the anatomical structure of the animal body, it is necessary to give a definition of a few of the terms which writers have carried into the vegetable.

A vessel, in the animal body, is a pipe or hollow tube for conveying blood, or any fluid, to different parts of the body.

By circulation is meant the course of the blood, which moves in a continued round in these vessels.

Reticular textures, or net works, &c. &c. &c. convey no idea of *use*; we will not, therefore, have any occasion to use them.

We do not mean, however, to enter into the minutiae of either system; for we do not pretend to such powers of vision as some, to see in the seed a complete tree, trunk, roots,

branches, leaves, flowers, and the fruit of many years to come; nor the nerves in the hairs of an old wig: And it is to be understood that we refer only to the more perfect animals, and to the more perfect vegetables, which we reckon trees.

A tree has commonly been divided into three parts—the trunk, the root, and branches; we have presumed to add a fourth, the bulb,* for reasons which will appear afterwards. The substance of the tree has likewise been divided into three,—the bark, the wood, and the pith: we shall consider each of these in the above order.

OF THE BARK.

The bark is a general covering, and consists of three coats or layers; the outmost is transverse, i. e. its fibres run across the tree at right angles; the next is longitudinal, and lies immediately under the former; the last is

* The bulb is that part which connects the trunk and root.

always evidently longitudinal, is a thin smooth membrane; we call this the periligneum, because it immediately surrounds the wood. The use of the bark is to defend the tree from the injuries of the air, and to form a passage for the sap to ascend between it and the wood, for the nourishment and growth of the tree.

OF THE TRANSVERSE BARK.

This bark consists of three coats or layers; the outermost is extremely thin and dry; the next in all trees is considerably stronger, but is very different in different species. In some, as the cherry, birch, &c. it is very strong; in the last, it consists of two layers which are easily separated. The last coat or layer is succulent, of a green colour, and extremely thin and delicate; this layer adheres more firmly to the longitudinal than to the transverse, but we have ranked it with the last, from the direction of its fibres. As the first and last of these coats are of little consideration in practice, except that the first or outermost, in some trees, shews an early symptom of constriction, by exfoliating in very small

scales, forming a rough appearance; but as it is scarcely perceptible in others, and as the last generally remains upon the longitudinal when the rest of the transverse bark is taken off, when we speak of this bark we refer to the middle or strong coat which is properly transverse.* In pear and apple trees this bark is very weak compared with the cherry, but is very different in different varieties of the pear and apple.

Duhamel says the direction of the fibres of this bark, which he calls epidermis,* is evidently transverse in the cherry, plum-tree, &c.; but there are others where it is not at all manifest.

I have not observed any, where it is not quite manifest by a trial of its strength.

He rightly observes, that this membrane is always thrown off by nature; but he is certainly mistaken, when he says it is always re-

* The outer coat of the transverse might more properly be called epidermis.

generated, and, like the epidermis on the human body, is continually and imperceptibly destroying and repairing itself.

I have never observed the transverse bark of a tree regenerated, nor the cuticle of the human body thrown off, but by disease or lesion.

That the regeneration of the vegetable epidermis is a mistake, may be learnt from Duhamel himself. He informs us that he took the bark entirely off a cherry tree, and defended it from the rays of the sun, and the injuries of the air; that a new bark was formed, and a new epidermis; "but this epidermis was quite different from the epidermis natural to the cherry tree:" then it was some other thing. He next tells us, that, in some cases, the epidermis is readily regenerated, and, in others, it is not regenerated at all. He says every body (*tout le monde*) may have observed that the epidermis does not regenerate on pears which have been damaged by *hail* or *caterpillar*. By a stretch of imagination we could believe that caterpillar, by some poisonous, chemical quality, acting on the bark

below, might produce such an effect; but it is impossible to conceive how hail, which acts purely mechanically, can prevent the regeneration of the epidermis, if it were naturally inclined to do so.

This, which he calls a new epidermis, is nothing but a thin pellicule without organization, formed of an *exsudation* from the longitudinal bark dried by the sun.

We cannot conceive for what purpose the epidermis should be constantly destroying and constantly repairing itself; nor can we see any analogy between the human and vegetable cuticle, except that they are both external coverings. The use of the one, which is given to man only, is to defend the tender feeling of the nerves from the rude contact of external substances. But surely trees cannot have more need of a cuticle for this purpose, than those animals to whom nature has given none.

The use of the transverse bark appears to be solely to preserve the cohesion of the longitudinal, and support the tree in its infant state; for we find this bark, as the tree ad-

vances in age and strength, universally thrown off.

This membrane, in some species of trees, as the cherry, the birch, &c. is very strong; in others, as the pear and apple, much weaker: but this want of strength in itself is compensated by its firmer adhesion to the longitudinal.

Duhamel says that, when a tree is in a full state of growth, the epidermis is easily separated from the bark below, what he calls *(Enveloppe cellulaire)*. This is certainly true in relation to those trees which have the transverse bark very strong, as the cherry, birch, &c.; but I never find it very easily separated in those which have it weak, as the pear and apple trees. He observes, as a wonderful circumstance, that those trees that are sickly *(languissants)*, and grow slowly, throw off the epidermis sooner than those that are healthy and grow faster. Mistaking the effect for the cause, is the reason of his surprise at this phenomenon: the tree does not throw off the bark sooner because it languishes, but it languishes because it is bark bound; and bursting the bark, is the only relief given by nature.

This bark contains little moisture, but expands in some trees to a considerable extent. It does not, however, increase in strength to the increase of the tree; nor does it expand during the whole growth of the tree, but, at a certain age, is ruptured and thrown off in dry flakes. The age at which this takes place, is different in different species of trees, and likewise varies from the situation and soil. The beech is the longest of any tree I am acquainted with, in throwing off the transverse bark, and rupturing the longitudinal; perhaps this may be the cause why the beech so often dies young.

The strength too of this bark seems to be influenced by climate, for I find it very different in strength, upon trees of the same kind growing upon walls, and upon those on standards; that on standards being much stronger than that on walls. This may be a criterion to judge what kinds are *fittest* for *standards*, and what for *walls*, and what are best suited to the climate.

As it is probable that soil may have similar effects with situation, at least that it may contri-

bute a share, I would recommend to the attention of the planter to study what soils most produce this effect on certain kinds of trees, and what not; which will enable him to discover what kinds are best suited to certain soils.

It is worth observing, that, though this bark is thrown off in flakes from the trunk and branches as the tree advances in age and size, it remains succulent on the roots during the life of the tree.

OF THE LONGITUDINAL OR MIDDLE BARK.

This bark lies immediately below the transverse. The thickness of this bark is always in proportion to the age of the tree, and in proportion to the age of that part of the tree which it covers; of consequence, thickest nearest the root, and gradually thinner towards the top and extremities of the branches.

In some, as the beech, the birch, &c. the fibres, or rather the fasciculi of fibres, running short way in straight lines, but dividing and

running obliquely into one another, and leaving interstices, gives it the appearance of a cellular substance, so that the direction of the fibres is scarcely observable. I have not, however, found any, where it could not be discovered by a trial of strength by breaking, or observed by a transverse cut with a blunt knife; and it may always be known from the form of these cells, which are oblong; and, as it is made up from the inmost barks of successive seasons, we conceive it must be longitudinal. In others, as the pear and apple tree, it is quite discernible, especially in the last, and in some varieties more than in others.

In some trees, as the elm, the oak, &c. it is not only discernible, but of immense strength; and it is made up of many layers, which separates easily, though not in *perfect* coats, as the fibres are interlaced with one another. This bark, in the cherry tree too, is of very considerable strength, and separates in the same way; but the fibres are not so much interlaced, which makes the cohesion of the bark weaker. But even in these, the most distinct, the organization of the outer part of this bark is always destroyed by age, and no direction

of fibres can be known, though the part below always remains unaltered, if not injured by the pressure or stricture of the outer part continuing too long.

This bark or covering increases in thickness as the tree advances in age, till, by its increase, together with that of the wood, the transverse bark is thrown off, when it is ruptured and imperfectly exfoliates in dry flakes. The longitudinal bark is composed of the *inmost barks* of preceding seasons, and, of consequence, consists of as many layers as the wood it covers is years old, *minus* one.

When this bark exfoliates, or is taken off, a new bark of the same kind is always generated below.—If the inmost bark is not destroyed, and even when it is, if to small extent, or if the wood is defended from the air by any covering, both will be regenerated.

If the inmost bark is regenerated, the longitudinal must be regenerated also, because the latter proceeds from the former.

In some trees this bark arrives at a very

great thickness, and when it is taken off regenerates and thickens amazingly fast. When a part is left, it exfoliates and is thrown off by the part which is formed below.

The use of this bark seems to be chiefly, if not solely, to keep the inmost bark moist and preserve its elasticity; for which purpose, from its spongy texture, it is well adapted; but, by age and exposure to the weather, it becomes so hard and rigid that it has a contrary effect; and we see nature, to relieve herself, throwing it off imperfectly in dry flakes.

OF THE INMOST BARK.

The last or inmost bark lies immediately under the former, next the wood.

As the inmost bark is the most essential to the tree, it will be necessary to be a little more particular on it. This bark is always evidently longitudinal, is thin and smooth on the side next the wood; but the opposite side has its fibres so interlaced with those of the

longitudinal, that it is difficult to separate them.

The inmost bark is always of close texture, and possesses a considerable degree of strength and elasticity. I had formerly said that I had not made a perfect distinction between this and the last mentioned bark, but the difference of structure, especially in some trees, the difference of qualities * and the difference of functions entitle it to a complete distinction. It is to be observed, however, that this bark passes every year to the longitudinal, while a new inmost bark is added next the alburnum.

When the inmost bark is taken off a tree or branch all round, to any considerable length, they will not live long beyond that part; they will, however, live and grow for some time from what they receive from the atmosphere, and from the earth by the alburnum, till it is dried by long exposure to the air, and rendered impervious to the sap.

* This difference of quality is particularly observable in the bark of the oak, the inmost containing none of the tannin.

When a part of this bark is taken off one side, the cut edges will adhere to the wood, and preserve a passage for the sap on the opposite side, and save the tree or branch. In this case the wood increases no more on the barked, but on the unbarked side. This shews that the wood is formed by a deposition from the sap, between the alburnum and inmost bark. When the inmost bark is taken off all round, to short extent, it will be regenerated.

How long a tree or branch will live after the inmost bark has been taken off all round, to a greater extent than it will regenerate, will depend upon different circumstances, as the species, the age and size of the tree or branch; the climate, and the capacity of the alburnum to resist the action of the air.

To what extent this bark will be regenerated, without the barked part being defended from the air, will depend upon the same circumstances as above; but we believe it will seldom exceed one-half inch. But if the barked part is defended from the air, it will be regenerated to almost any extent.

We have observed that when this bark has been taken off all round, to a greater extent than it will regenerate, and the barked part left exposed to the air, the part of the tree or branch above the incision increases more in thickness for one year than the part below: the same effect takes place although the part is covered, but the bark is regenerated and the branch is preserved.

This, however, only takes place when there are more lateral branches and leaves above the incision than below it, because the part below the incision having less surface exposed to the air, will receive less of that maturing influence from the atmosphere which converts the sap into wood; the sap going to the formation of new branches, to supply the loss it has sustained by cutting off the communication it had with the atmosphere; whereas the part above the incision, having more surface exposed to the air, will receive more of that influence, to convert into wood and fruit that sap it receives from the earth by the alburnum.

It has been observed, that where annular incisions of the bark to the wood have been

made on the trunk or branches of a tree, especially the *vine*, that the fruit above these incisions comes sooner to maturity, a larger size, and finer flavour.

The result of this experiment has been adduced as a proof of a descending sap, because it is concluded that the incision prevents the descent of the sap, which then goes to the nourishment of the fruit instead of descending down the tree; and this too has been given as a reason, why old fruit trees bear better than young ones; the hard rigid bark stopping the descent of the sap. But we can easily conceive how the fruit may ripen sooner, and, of *consequence*, come to a larger size, and have a finer flavour, without the *supposition* of a descending sap; because the tree above the barked part being deprived of a part of that cold sap which it draws from the earth, and at the same time having the full influence of the atmosphere, heat and light, the sap which it receives by the alburnum will be sooner converted into nourishment for wood and fruit.

If the whole sap or nourishment from the earth ascended by the alburnum, as some say,

and the descent by the *inner bark* stopt, the part above the incision would soon be surcharged and disease ensue, we might say apoplexy! and the part below, being deprived of the benefit of the atmosphere, would certainly die. For we are of opinion, that if a tree were completely deprived of the benefit of *either* earth or atmosphere, it could not live (8*th.*) But in this case it is supported, *above* the incision, from the earth, by the alburnum; and *below*, from the atmosphere, by the lateral branches. Here we are presented with two beautiful instances of that principle of self-preservation, which nature has implanted in every animal and every vegetable for the preservation of the species (6*th*): when a ring of this bark is taken off, the part below the ring, being deprived of the benefit of the atmosphere, sends out new branches and leaves; and the part above, being deprived of the benefit of the earth, sends out new roots to supply the loss.

As the animal body increases by *continued extension* of all the parts, it is necessary there should be a continued circulation of nourishment through all these parts.

But as the tree increases by *addition*, and that only *periodically*; and as none of these substances, formed in different parts of the vegetable, are returned into the system, as in the animal, we can see no necessity for a circulation or a descending sap; and as a tree increases, *caeteris paribus*, in proportion to the quantity of vegetable matter in the soil, we conceive the matter of increase arises solely from the earth; and, as it ascends, is converted into wood and fruit by the action of heat and light; and, as the action of these, at least heat, gives motion to the sap when they cease to act, all motion of the sap, and increase of the tree, is suspended till the return of the season when their powers are again exerted.

Though we know that air is absolutely necessary for the formation of both wood and fruit, the subject is yet in too much obscurity for us to give a name to that which the tree receives from the atmosphere. But we know that the principal agents are heat and light; and that their influence penetrates to every part of the tree; but we cannot venture to call it sap or substance from which the wood and fruit are formed, more than we can call the

heat of a hen the sap or substance from which the chicken is formed.

There is no doubt, however, that the vegetable takes up a great proportion of that part of the atmospheric air, called inflammable air, or hydrogen; and rejects that part, called vital air, or oxygen; that the animal, on the contrary, takes up the vital air, or oxygene, and rejects the inflammable, or hydrogen; hence it appears that the animal and vegetable are so far dependant on one another.* But it appears that there is something wanting to complete our knowledge: for the vegetable, though exposed to the air, cannot live and grow, nor produce any of those substances natural to it, as essential oils, &c. without the agency of light. But the privation of light

* Although the animal and vegetable are thus subservient to one another, we believe that every part of the atmospheric air is, in some way or other, necessary to both animal and vegetable. There can be no doubt that it is long exposure to the air, which gives the acid, the bitter, the astringent, and tannin to the bark, for the new or last formed bark does not possess these qualities. It is probable that oxygen is the principal agent in forming these.

does not deprive the animal of any of those properties or functions, as both earth and air are necessary for the growth of the tree, and production of fruit; we conceive, for this end, there is a just proportion between what the tree receives from the earth, and what it receives from the atmosphere.

If both earth and air are necessary for the *life and existence* of a tree, it follows that a certain proportion is necessary to constitute *health.* This proportion will be different in different kinds of trees, and likewise vary from the situation and soil; and we conceive that custom will do a great deal in the vegetable as well as in the animal; for we have repeatedly observed trees growing in a wet soil not hurt by irrigation, while those growing in a dry, were entirely and suddenly killed by it.

We know, from trees upon south walls, hot walls, and branches turned into forcing houses, that the air, heat, and light, have more influence on maturing the fruit, than the earth. It is therefore fair to conclude, that where the maturing principle from the atmosphere predominates, the fruit will ripen sooner; and it may

be made to predominate, either by increasing it, as by south walls, hot walls, &c.; or by diminishing the growing principle or cold sap from the earth, by annular barking, transverse incisions of the inmost bark, and ligatures.

The first of these methods,—increasing the influence of the atmosphere by forcing houses, hot walls, and south walls,—is very limited. The last,—diminishing the quantity of sap from the earth by annular barking,—is universal, and at the same time much more powerful; besides, it is well known that fruit growing upon walls is never equal in quality, taste, and flavour, to the same kind growing upon standards: we can give no reason for this difference, but the difference of light.

From these observations, and particularly from the experiments of annular barking, &c., it appears that the fruit does not ripen sooner from the stoppage of the descending, but from the stoppage of a part of the ascending sap; and, on the same principle, annular barking, transverse incisions of the inmost bark, and ligatures, by cutting off a part of the cold sap

from the earth, and casting* the balance in favour of the atmosphere, throw the tree or branch sooner into a bearing state; and we believe that the barrenness and canker of fruit trees, in this climate, is not solely and directly owing to the want of heat, but partly to the great quantity of moisture with which the earth is almost constantly loaded.

In short, we conceive that fruit will ripen sooner or later, as the *growing* principle from the earth, or *maturing* principle from the atmosphere, prevail; but we do not believe, when deprived of any part of the former, that it will, *caeteris paribus*, arrive at a greater size.

On the same principle we find corn and other vegetables ripen sooner in a dry and clear season, than in a wet and cloudy one; and, likewise, on a dry, sooner than on a wet soil; but we certainly do not find them arrive at a greater size or stature.

The experiment on the vine is not conclusive on this point; for fruit does not in-

* Or, more properly speaking, restoring.

crease during the time of growth in an arithmetical progression. From its formation it increases very slowly, till it begin to ripen; after which it increases very rapidly: so, in the unbarked tree, the cold comes on before the fruit arrive at that point from which its growth is accelerated, and stops it altogether.

So this question occurs, Would the unbarked tree, were the weather to continue favourable, produce fruit of equal size with the barked one?

This question can only be determined in a warmer climate, a forcing house, or on such trees as bring their fruit to maturity very early in the season. I have no hesitation, however, to give an answer to this question, *a priori*, that the unbarked tree will certainly produce the largest fruit.

Why old trees bear better than young ones, depends upon another cause, which will appear afterwards. This cause, however, will make them bring their fruit sooner to maturity, the same as a ligature. That ripe fruit

should have a finer flavour than unripe, surely cannot be wonderful.

There is another circumstance attending annular incisions of the inmost bark, which, at first thought, would still *more* suggest the idea of a descending sap; that is, that bulbs are formed at the upper part of the incision. But this is only the principle of self-preservation implanted by nature in every animal and every vegetable. The tree, when deprived of that support it receives from the earth by the roots, attempts to send out new roots by forming bulbs, as preparatory to new roots, and only requires earth within its reach to accomplish this end. Agreeable to this, we find those trees which grow readily by cuttings, forming bulbs or burr-knots on every part from which they send out roots when planted in the ground. But there is no occasion for a descending sap for this purpose, because, when the sap above the incision is deprived of the support of the bark below, it will naturally, from its gravity, fall down and form a bulb; and were it not for that law of nature by which she repairs losses, which in this case is brought about by the action of the air making the cut edge of the

bark contract and cling to the wood, the whole sap would run out; as the whole blood in the animal body would flow from the rupture of the smallest blood-vessel, did not the vessel contract, and the blood coagulate, to shut up the wound. There cannot be a clearer proof that the sap ascends from the earth principally by the inmost bark; that is, between the inmost bark and alburnum; for when the communication is cut off, the tree attempts to open a new communication with the earth by forming new roots. If the sap ascended wholly by the alburnum, there would be no occasion for this.

When an annular incision of the inmost bark is made upon a tree or branch, the part above the incision, being deprived of what it requires from the earth, sends out new roots; and the part below, being deprived of what it derived from the atmosphere, sends out new branches to supply the defect.

It is to be observed, that the privation in both cases is only partial; for if it were total, the part would certainly perish.

Thus we see any part of a tree prepared to grow to either roots or branches, according as it is circumstanced.

I cannot here omit taking notice of a practice I have been informed of by an intelligent gentleman, Major Weir, commonly followed in India, of making new trees of the branches of old ones. The method is this: bark a branch two or three inches in length; fix a ball of earth and cow-dung on the upper part of the incision, including a part of the bark, leaving the under part exposed to the air; above the ball suspend a bottle or jar filled with water; put one end of a worsted thread into the water, let the other end be fixed in the ball; the thread, by capillary attraction, will draw the water from the bottle to the ball, and keep it constantly moist; roots are formed in the ball from the branch which is cut off, and planted in the ground for a new tree.

I have taken notice of this practice, because I consider it both curious and useful, and not generally known in this country.

Some late writers have not only given it as

their opinion, but fixed it down as a certainty, that the bark is a congeries of roots; that the *new buds* sending *down roots* or radicles to draw nourishment from the earth, form an additional layer to the bark.

We have heard of castles built in the air, but these always fall from want of foundation; but it would appear that *buds built in the air* make a foundation for themselves.

It is justly observed by Mr Knight, "that if the inner bark, and annual layers of wood, were formed by *radicles*, descending from the buds above, the stock must ultimately become covered with wood similar to that of the graft, by being formed of the radicles of its buds; but the wood and bark of the graft never descend a single line below the original point of junction."

It is well known, from annular barking, that in no case will the bark descend one inch.

On the other hand, it is *now* equally well known, that if the inmost bark is preserved, and the outer bark taken off, it will send out

buds in every part of the oldest tree: in short, the bud is not the parent, but rather the offspring of the bark.

But, more properly speaking, the bud is the offspring of the alburnum, for it arises out of the alburnum, and in its passage through the bark carries the periligneum along with it.

It is true that where a cutting grows, the roots spring from the bark, and not from the wood; but this only shews that the principal conductor of the sap from the roots to the bud is the bark, and this conductor is the inmost bark in common with the alburnum. Hence, as a *new inmost bark* is added every year next the alburnum, the conductor of nourishment to the *last buds* will always be the *inmost bark*; and hence the bark, or conductor of nourishment to the *former* buds, being every year removed farther from the inmost, where the sap ascends, these buds from want of nourishment die, and the branches decay and fall off.

Accordingly we observe the trees seldom send out buds or bear fruit on *wood* above five or six years old; and, as they do not common-

ly bear on *wood* under three years old, we seldom have fruit on the same wood above three or four years; and we find the trees seldom canker till they arrive at this age.

Besides maturing the fruit, annular barking will throw the tree or branch almost immediately into a bearing state; that is, if it is barked in one season it will be put into a bearing state the next; but if the barked part is not defended from the air by some covering, it is at the risk of losing the tree or branch. If it is carefully covered with a piece of rag, the tree or branch will be preserved, the ring filled up with new bark, in four or five weeks, sometimes sooner, the wood increased, the fruit larger, sooner ripe, and of finer flavour. Partial ringing; that is, cutting out a ring one half round the circumference, a simple transverse incision through the inmost bark, and a ligature, have similar effects; but less in degree and less certain. In the regeneration of the bark upon the ring, it proceeds chiefly from above downwards, though some small advance is made from below upwards; sometimes they meet nearly halfway. I find it has been a practice with some, to cut the ring so narrow that

it may fill up with new bark without covering; but this is very uncertain, for I have often found that not a single hair's breadth of new bark was produced, either above or below. Ligatures are not advisable, because they injure the health of the tree or branch.

It is worth taking notice of the force exerted by the growth of the wood, in cases of annular barking. We know that a very weak ligature about a tree or branch will stop the growth and increase in that part altogether; but, in cases of annular barking, I have frequently known it rupture three or four rounds of a strong bandage.

Annular barking shews two things very important in vegetable physiology: the part above the incision, sending out roots, shews that the nourishment from the earth ascends chiefly between the inmost bark and alburnum; and the part below, sending out branches, shews that the influence of the atmosphere is communicated chiefly through the same channel. Indeed the one is a necessary consequence of the other; for where the most sap is, there must the influence of the atmosphere be

most required to convert it into wood and bark.

Duhamel has placed all his vessels, which carry the nourishment to the tree in these two last barks, arteries, lymphatic vessels, proper vessels, &c. It is truly astonishing how he could entertain such an idea after his own observations and experiments; for he observes, that there is nothing to be found in a tree similar to the vessels in the animal; that is, pipes or tubes.

He next informs us, that he took the bark entirely off a tree, and covered it with wax and turpentine; that a new bark was generated below the wax and turpentine.

I have done the same thing hundreds of times with a piece of rag, and found the same result.

Hence it appears that all the functions were performed by the wax and turpentine, and by the rag, which were performed by the bark; and we can scarcely imagine that there were

arteries, lymphatics, &c. in the wax and turpentine, or in the rag.

There is certainly nothing in a tree similar to the blood or lymphatic vessels in the animal body! that is, pipes, or hollow tubes. If there were, motion could neither be given nor continued in them without a strong *vis a tergo*, and a contractile power of these vessels themselves, which vegetables do not possess.

If there were any analogy between the vessels in the animal and vegetable, we should find these vessels increase, in capacity or diameter, in proportion to the increase of the body, because it requires more nourishment: but we find no such thing. In the largest tree we cannot discover a vessel, even by the help of a microscope; besides, we should find the reducent vessels equal in power or capacity to the adducent, which cannot be, without supposing that there are as many circulations as the tree is years old.

What has been taken for vessels in the tree are merely canals or interstices, formed by the fasciculi of fibres; and were these to contract

on one canal, it would dilate another; and, thus, as much impede the motion of the sap as promote it; whereas the vessels in the animal are distinct tubes which contract, each by itself, without affecting another.

The motion of the blood in the animal body has properly been termed circulation, because it is constantly moving in a circle from the heart in one set of vessels, and returning in another set. But there is no such thing in the vegetable; for, if there were, there behoved to be a centre of motion within the tree itself, similar to the heart in the animal; but no such thing can be found.

The only thing in a tree, which can in any measure be compared to the animal vessels, is the whole circumference of the bark, taken as a tube, whose cavity is filled with the wood, but not so close as to prevent the sap passing between it and the sides of the vessels, and the cavity in the centre of the tree which contains the pith.

The motion of the fluids in the animal and vegetable, is very different in velocity: in the

animal it is very rapid: in the vegetable extremely slow; and it is very differently affected by temperature. By a very moderate degree of cold it is entirely suspended in the vegetable; by a very low degree of temperature it is not at all affected in the animal.

Here we are naturally led to consider by what power or agency motion is given to the sap in vegetables.

From what has been premised, it is clear, it must be totally different from that in animals.

We know that all fluids press *undiquaque*, and are only kept in their place by the pressure of the atmosphere. If this pressure is taken off, they will ascend in any tube, without any action of the tube itself, or any *vis a tergo*, but the pressure of the atmosphere on the surface of the fluid in which the tube is placed.

We likewise know, that if the particles of any body are so minutely divided as to become specifically lighter than air, they will ascend without any other power whatever; and we

can conceive particles so minutely divided as to be specifically lighter than air without being converted into gass.

We are well acquainted with what is called capillary attraction. When we take all these circumstances into account, and that the roots of vegetables are truly capillary, we may conceive how motion is begun and carried on in the vegetable; i. e. we may understand it as well as any other operation of nature, for our knowledge is only comparative. When any new phenomenon occurs, we say we understand it, or do not understand it, according as we are acquainted or unacquainted with any thing similar to it; though we do not *absolutely* understand the one more than the other, but have only been longer acquainted with it. Indeed the present appears to be one of the most simple operations of nature. The sap is drawn from the earth by the capillary roots, and ascends by the fibres of the large roots to the bulb, from whence it is carried, by the fibres of the periligneum and alburnum, to every part of the trunk and branches: for we know there is no necessity for pipes or hollow tubes in this kind of motion; the fluids ascending readily

by any small thread or fibre; and for this end we find the fibres of both the inmost bark and alburnum always longitudinal, from the extremities of the roots to the extremities of the branches.

Hence it is easy to see the great use of the inmost bark. Its fibres are always extremely fine for conducting the sap; its texture is close, which prevents the evaporation of the sap ascending between it and the wood; and its near contiguity to the alburnum prevents the sap running into a body too heavy for ascent.

So we consider the interstice between the wood and bark round the whole circumference as one capillary canal, the sap ascending by the fibres of both wood and bark. Hence we always find here the greatest quantity of sap when the tree is in a state of growth. From this sap is formed an additional layer to the wood, and a new coat to the bark, every year.

The inmost bark is only a great number of capillary fibres set in a circle, and those of the alburnum corresponding with them: in

short, the tree is nothing but a bundle of capillary fibres.

With regard to the descent of the sap, I can see no evidence of it; and, if I saw nothing to the contrary, I might perhaps, like others, believe it *without evidence*. We find there are two opinions among professional men of a descending sap: one, that the sap ascends in spring, and descends in autumn: the other, that there is a continued ascent and descent at the same time; that the sap ascends in one set of vessels and descends in another set, like the circulation of the blood in the animal body. We look upon both these opinions equally void of foundation. With regard to the first, the sap cannot remain in the roots, for they have not capacity to contain it; and we do not find them fuller of sap in winter than in summer. We cannot imagine that it passes every season into the ground; and that the capillary roots have to extract *that* every year what they had done the year before; and we do not find the ground about the roots more moist in autumn, after the supposed descent of the sap, than in summer. Further, if the sap descended every autumn to the roots or earth, we should find

the new vegetation in spring begin at the root and gradually ascend; but we find no such thing; we find the bark relaxed, the buds swell, and the blossom and leaves expand, as soon at the top as at the root of the tree; and we find the same appearance take place at the extremities of the branches as soon as at the trunk.

When the tree and branches are peeled so near that the action of the air evaporates the sap, dries the periligneum, and contracts the alburnum to a certain degree, without stopping the ascent of the sap altogether, a different phenomenon takes place. The vegetation in spring begins at the root and proceeds upwards; the buds on the branches swell, the blossom opens, and the leaves expand, first at the trunk, and proceed gradually to the extremities; and the progress is extremely slow; the blossom and leaves next the trunk being fully expanded a month before those at the extremities shew any symptom of life. But notwithstanding this difference of the blossom, however strange it may appear, the fruit on the extremities of these branches, comes as soon to maturity as on the other parts of the tree. This

might be a mean of preserving the fruit in this climate, by keeping back the blossom till the severe frosts are past, which so often destroy it. There is, however, a risk of killing the branch; therefore, if any person wishes to try this method, I would advise him to peel only one side of the branch, which will retard the blossom and avoid danger; and not to peel earlier than the middle of March, after the sap is set in motion.

It is observed by a late writer, that a thick covering of rigid and unexpansible bark greatly impedes the *descent* of the sap; and of consequence kills the tree. It is a well known fact, and observed by the same writer, that the roots of trees, and a part near them, are more durable than the trunk and branches. May it not be asked, if an interruption to the *descent* of the sap kill the tree, how do the roots and part next the root live after this?

Nothing can be plainer than that it is an interruption to the *ascent* of the sap that kills the tree; of consequence, the higher you go, the tree will be more scantily supplied, and die first at the top and extremities of the branches,

descend to the larger branches, to the trunk, and last of all to the bulb and roots.

Here we may observe the difference between the living and dead fibre, in the vegetable as well as in the animal. When a stake of dead wood is driven into the ground, that part near the surface decays and rots sooner than the part above; but, in the living tree, it is quite the reverse.

It appears very strange indeed, that a few hours of a cold frosty night, which effectually checks vegetation, should send all the sap of a large tree to the ground, and a few warm days send it all up again. We have, therefore, every reason to conclude, that the descent of the sap is merely imaginary. We know that it is heat which promotes the ascent of the sap, by relaxing the solids, and rarefying the fluids; and we know that it is cold which stops it, by contracting the solids and condensing the fluids. The application of cold must, therefore, *prevent* the descent of the sap, because the trunk and larger branches being as much exposed as the smaller, the sap there will be as soon con-

densed, and the bark contracted; which will stop the return of the sap from the extremities.

I am aware that an argument might have formerly been used against this idea; that the bark on the trunk and larger branches, being thicker than on the smaller, would be longer in being affected by the cold, and thus allow the sap to descend. But, in answer to this, in these trees where the outer bark has been taken off the trunk and larger branches, and the remaining bark left much thinner than that on the smaller branches, there is not the smallest appearance of any interruption to the descent of the sap, which certainly would appear if it did descend. We are, therefore, obliged to conclude, that the sap of a tree does not descend; but that it is merely condensed by the cold *, and its passage shut up; that as soon as it receives the heat in spring it is rarefied, the bark relaxed, the passages opened; and it appears in every part of the tree at the same time, according as the heat has reached it, and the impetus given at the root. For every body knows, that where any impetus is given to one

* In severe frosts, we find the sap actually frozen into ice.

end of a continued body, the motion begins as soon at the opposite end, as at *that* where the impetus is given.

With regard to the second opinion, of a continued circulation, or ascent of the sap, in one set of vessels, and descent in another, we have again to observe, that no such vessels have yet been discovered; and we may add, never will.

But they build upon imagination, what they call hypothesis, and explain it thus:

"The food and moisture which is collected from the earth, by the roots, is *absorbed* through the *pores* of the bark;" (the roots first collect the sap, and then absorb it; how do they collect it?—into pools, we suppose; from which the pores drink it up), "and ascends wholly through the alburnum, or sap-wood of the root and trunk, and is by this substance then, independently of the bark, carried to these buds which produce the annual shoots of the succeeding seasons. In the buds and annual shoots, the sap is received by another *species* of vessels, and is impelled forward, by a

new agent, into the leaves." What *species of vessels? what new agent?* no matter, it is *another species*, and a *new agent.*

"From the leaf, the sap is returned through *another* set of vessels," (what other set?—nobody knows), into the *inner bark; and, in its passage downwards,* deposits the new matter which annually forms the increase and extension of the branches, the trunk and root;" so the *ascending* sap enters the root by the *pores* of the bark, into the alburnum, and the *descending* sap comes down the inner bark.—What happens when they meet at those *pores?* does the *ascending* sap pass through the *descending* sap, in its passage to the alburnum? or does the *descending* sap pass through the *ascending* sap, in its passage downwards? this must either happen, which is absurd, or one of three things must take place:

1*st*, When the two saps meet, the descending sap must carry the ascending sap down along with it; what then will the *trunk* and *branches* receive from the earth?—nothing; or,

2dly, The ascending sap must carry the descending sap up with it; what then will the root receive from the atmosphere?—nothing.

Or, *lastly*, they must produce a stagnation, and burst out laterally. This would be a good way of accounting for the canker. Here, again, we meet with our old friends, the devil and the baker*. If this is the course of circulation, what is the course when the tree is planted with its head downmost? or when it is bent like a bow, and both ends planted in the ground? what is to be done when the sap ascends from both ends, to the top of the arch? or when a bud is inserted, with the eye inverted to the root? what takes place in the case of inarching?

It is admitted, which no one denies, that "the progress of the ascending sap is accelerated by heat." It would appear, then, that the ascending and descending saps are of very opposite tempers; for heat makes the one ascend, and the other descend; and, what is more extraordinary, what *descends*, being in

* See Introduction to first Edition.

the bark, is more exposed to the heat, than what *ascends* in the wood. But, perhaps, a certain degree of heat may make the sap ascend, and a greater degree may make it descend. This is a chemical discovery, which has been reserved for the vegetable philosophers of the present age.

The sap ascends by the alburnum to the leaves, and there is *changed*, *elaborated* and *concocted*, and then returned back through the inner bark, (which must be very thin next the leaves,) to its place of destination. Can it not be *changed*, *elaborated* and *concocted* in that place, without being sent to another, and returned? This notion is merely hypothetic, and not founded on either reason or experience, but in opposition to both. I may as well *suppose* a circulation, or an ascending and descending sap, between the hen and the egg; that it ascended from the egg to the hen, there to be elaborated and sent down again to the egg; or, I may *suppose* vessels, arteries, lymphatics, &c. in a candle-wick, in which the grease ascends, descends, &c. &c.

If there were a circulation in the tree, like that in the animal body, the vessels which return the sap from the extremities, ought to be equal, in capacity, to those which carry it to the extremities: this cannot be in a tree; for a tree of 100 years old, has 100 coats of bark next the root, but only one at the extremities.

Every body knows, that if the return of the blood from the head, in the veins, is stopt, or even diminished, while the influx by the arteries continues undiminished, apoplexy and death immediately follow. The same consequence would follow in a tree, in the case of annular barking, did a circulation exist in a tree.

There are no vessels, properly speaking, in a tree: whatever direction the sap may move in, it passes along the fibres, and these are every where interlaced with one another, except the alburnum and inmost bark; and, if the fibres of these are not interwoven, the fluid between them is common to both, and is carried on by the fibres of both. It is supposed that the notion of circulation in the tree was first created

when Dr. Harvey discovered the circulation of the blood. Cotemporary doctors finding all their efforts to deprive Harvey of the merit fruitless,—that the discovery was complete, and nothing left for them in the animal on that head, resolved to make a discovery for themselves, in the vegetable, similar to Harvey's; and some of them have discovered *valves* in the vessels of a tree.

We are told that "the motion given to the trunk and branches by the *winds* accelerates the descent of the sap;" shakes it down, we suppose, like corn in a sack. Query: Will not the same motion help to shake down the ascending sap also? that "this motion is wholly lost by the *grafted* tree when deprived of its branches; the sap in consequence stagnates under the rigid cincture of the external bark, and the death of the tree is the natural consequence." As the winds do not constantly blow so as to shake the trunk, may not the life of the *grafted* tree be preserved by giving it a shake now and then with the hand? We conceive the death of the tree is owing to a very different cause, viz. the privation of the benefit of the atmosphere (8*th*). But the tree will

not die if the grafts take; because they communicate the influence of the atmosphere to the trunk: nor does the tree always die although the branches are cut off, and the external bark left on; because the bark near the cut being relaxed, it sends out new branches to supply the loss of those cut off (11*th*). It is, notwithstanding, true, that if the branches, leaves or buds are repeatedly taken off as they appear, nature, baffled in her attempts to preserve life, and tired out, will give up her efforts and the tree perish. Every body knows that the motion given by the winds frequently kills trees, especially new planted, before their roots are firmly fixed in the ground.

It seems to be the custom of gardeners, botanists, and other vegetable physiologists, always to draw conclusions directly opposite to what their own observations and experiments point out.

Thus they have shewn by experiment, that a tree, entirely deprived of the bark, if covered with an unorganized substance, will be nourished and grow, and a new bark be generated; and yet they conclude, that the vessels which

carry the nourishment to the tree, are seated in the bark.

They have observed that trees are seldom hurt by fire; in summer, when fire and lightning are most frequent, not a tree perhaps for many miles in a whole summer; but they can burn all the fruit-trees in the country, by the fire of one *frosty* night in spring.

A tree does not bear because it has too much what they call superfluous sap, and it does not bear because it has too much wood: should not the superfluous sap support the superfluous wood? and the superfluous wood consume the superfluous sap? but we confess we do not understand the meaning of *superfluous* in this case.

We are told that trees canker, because their roots run into a cold till or barren subsoil; and yet we are informed, that in rich soils, as old fold-yards, &c., they can scarcely preserve the native crab from canker.

Vermin are brought from a foreign country, by the east wind, to destroy the blossom, &c.

If such notions are imbibed, no discovery can be made, for the mind is filled and fettered with mysteries, absurdities, and contradictions, from which it never can get free.

We hear that experiments are now making to prove, that cold is not the absence of heat, because cold radiates. Some author, I think, the spectator, informs us of a sect of philosophers, who held, that darkness was not the absence of light, but proceeded from certain dark stars, which send forth rays of darkness, as the sun does rays of light.

We have no idea of dark stars in the natural, though some think they may exist in the moral world; in which constellation we can have no doubt to place both these sects of modern philosophers.

On the above mode of reasoning, we can easily account for cold; for heat, as well as light, proceeds from the sun; and why not cold from cold stars? which will be constantly issuing forth cold, while the sun is sending out heat. I find it will be impossible to get

rid of our old companions, the devil and the baker. *

When a man adopts an opinion, he forms his theory accordingly, and makes every fact and experiment bend to it; as a person who believes in dreams, thinks any occurrence that follows, a fulfilment of his dream.

OF THE WOOD.

The wood consists of two parts, the alburnum or sap-wood, and the real wood.

The alburnum is the external part, next the bark; it is soft and full of longitudinal canals, which allow the sap to ascend by the fasciculi of fibres, which form these canals.

Between this wood and the bark, is the great canal, by which the tree is chiefly nourished, and from which it receives its increase. As the tree advances in age, part of the alburnum is converted into real wood,

* Vide Introduction to former Edition.

while new alburnum is added externally to the old.

The real wood is in the centre, surrounded by the alburnum. This wood is not formed till the tree is of considerable size; but the time is very different, in different species of trees. This part of the wood is hard and compact, and gives strength to the tree.

There are many species of trees, where no distinction can be made between the alburnum and real wood: the beech is an example of this kind.

OF THE PITH.

The pith lies in the centre of the trunk and branches; is of a spongy cellular texture.

There is a wide difference of opinion respecting the use of this substance, some thinking it essentially necessary to the existence and growth of the tree, while others think it of no use at all.

This difference of opinion, like that on many other subjects, seems to have arisen from a misunderstanding of one another, and from a misunderstanding of the subject itself.

It is worth observation, that the roots have not this substance at any period: it begins imperceptibly small at the lower part of the bulb, and gradually increases in size to the trunk.

We consider the bulb as the centre or focus of all the members of the tree; and from this point the roots proceed downwards, and the trunk upwards. If the trunk is cut away, and the bulb left, a number of trunks arise from it, each of which receives its pith there; but, if the bulb is cut away, the roots die, unless they are exposed to the air. If, however, a graft is put upon any of the roots, that root will live, the graft grow, and make a new tree; which shews that air, as well as earth, is as necessary for the life of the root, as it is for that of the trunk: the graft in this case communicating to the root, what is necessary from the air, while the root communicates to the graft, what is necessary from the earth.

That the pith is essentially necessary at an early period, there can be no doubt, for then there is no wood, nothing but pith and bark: the pith is then full of sap, like a wet sponge, or a bit of new made cheese, and the wood is formed between it and the bark.

If the pith, as some say, were obliterated altogether, as the tree advances in age, and size, we would conclude, that it was only necessary at an early period; but, as it is found existing in all trees, of great age and size, and of the hardest and most compact wood, we are obliged to conclude, that it is necessary during the whole growth of the tree; and if it is ever obliterated at all, the tree is then at its acme, and will cease to increase, though it may continue for some space to live.

As this substance is found only in the trunk and branches, and not in the roots; and, as the roots will not grow without a communication between the earth and atmosphere, by means of a trunk or branch, it certainly is not irrational to conclude, that the pith is necessary, for conveying something from the atmosphere, requisite to the root.

This is the only channel, where we can form any idea of a descending sap.

How far any thing *like a sap* may ascend, or descend in this channel, we will not venture to say, without further experience; but we know that water will pass through it either way.

It is true that a tree or branch will grow after the pith has been cut out, from which it has been concluded, that it is not absolutely necessary to the growth and existence of the tree. But I suspect the experiments made by others, like those hitherto made by myself, were not conclusive, and were made a considerable way from the root, so that the remaining part of the pith, below the cut, might convey from the atmosphere to the root, whilst the alburnum and remaining bark might convey from the earth, what was sufficient to preserve both alive, and even to grow.

To make the experiment conclusive, it will be necessary to cut out the pith, where it ends in the lower part of the bulb.

OF THE SECRETORY ORGANS OF TREES.

The secretory organs of trees are very few, and seem to be contained in the buds only; and these are only of two kinds; one for the wood, and another for the fruit: these may be called vegetable glands.

When we descend to the minutiae of nature, dissection and microscopical observation serve us nothing; we cannot, therefore, know the internal structure of a gland or bud; but the difference of the buds which produce wood from those which produce fruit, is clearly marked by their external appearance; the wood buds being smaller and more pointed than the fruit buds.

The practice of budding clearly shews, that the buds are glands or secretory organs, and separate from the general mass of fluids in the stock, what is proper to their own species; for neither the wood nor fruit which they produce, partake in the smallest degree of the

stock on which they are inserted, but entirely of the nature of the tree from which they are taken. Hence it appears, that health is all that is necessary in a stock. It is difficult to understand how the different substances found in trees, as gums, resins, &c., are formed; but it would appear that they are in a state of solution in the general mass of fluids, and are formed by deposition and evaporation; for, when the tree is wounded, they flow out in a liquid form, and afterwards concrete. The same thing happens when the tree is cut down, when all motion of the fluids is gone.

The buds, too, are the organs by which the influence of the atmosphere is communicated to the tree; and either wood or fruit buds are capable of performing this office; for a scion without a bud will not take, nor will a bud grow unless it is exposed to the air.

As the buds communicate directly with the wood, it is probable they convey the influence of the atmosphere, particularly to the pith, which conveys it to the root.

It has already been observed, that the idea of vessels carrying particular kinds of fluids, is without foundation: for there is nothing which can be compared to a vessel but two; that is, the cavity of the bark round the wood, where all the fluids are mixed, and the cavity which contains the pith, in the centre of the tree. But, allowing the canals in the wood and bark to be called vessels, for I do not wish to argue upon words, it is certain, and admitted by all writers on the subject, that these vessels communicate with one another, by the fibres of one fasciculus dividing and joining another, so that the whole fluids must likewise be mixed in them. How the different qualities, found in different parts of the tree, are produced, is still more difficult to understand; but there can be no doubt that these are produced by the action of air and light, in conjunction with the organization of the particular part, upon the general mass of fluids.—This is a subject which I am afraid we shall never be able to comprehend. I am, however, very far from discouraging enquiry: on the contrary, I recommend it to the study of those who have time and opportunity; for I am per-

suaded that much information, both curious and useful, may be derived from this source.

It seems to be a very general opinion, that the roots of vegetables have the power of extracting from the earth juices peculiar to their own species; and that trees have particular roots which extract particular juices, some for fruit, and others wood.—We do not understand how fruit and wood buds are formed, more than we understand how the different glands in the animal body are formed. It appears, however, from annular barking, ligatures, and from difference of climate and soil, that the formation of flower and leaf buds depends on the balance between the influence of the atmosphere, and the sap ascending from the earth. But enough has already been said, to shew that there is no foundation for the above opinion; that the juices, drawn from the earth, are all mixed in the tree in a general mass, and are separated by the organization of the particular plant, and part of a tree, in conjunction with the action of the atmosphere. Thus, an apple bud inserted in a pear tree, produces wood, flowers, leaves, and fruit, as perfectly apple as the tree from which the bud

was taken, although the branches both above and below are pear. From this idea of the roots of vegetables drawing particular juices from the earth, has arisen the notion of the necessity of changing crops; but, excepting the advantages arising from conducting agriculture, as preparing the ground, cleaning, sowing, reaping, &c., I can see no other benefit from it.

We conceive *that matter*, which is the food of vegetables, all the same, whether derived from animal or vegetable, or by whatever root extracted; that it is dissolved in the earth, ascends in a liquid form, and is converted into solids by the action of the atmosphere. We can give no other name to this vegetable food, this animal and vegetable matter, than that given by the great Buffon, "living organic particles," in which nature abounds, and which require only a concurrence of circumstances to form them into different bodies. From this, probably, has arisen the ancient doctrine of transmigration.

Every body knows that onions succeed as well, and rather better, after onions, than afte

any other crop; and why onions more than any other vegetable?

I have seen three successive crops of wheat, and all most abundant.

I have peppermint growing on ground where no other crop but peppermint has grown for thirty years, and it certainly produces it as good and as abundant as it did at first; and yields as much essential oil as that on ground where peppermint never grew before.

However great the difference of trees and vegetables above ground, we do not find the same difference below, especially of these parts,—the capillary roots,—which draw the nourishment from the earth. There are not, perhaps, two trees more different above ground than the apple or pear, and the cherry tree; this is particularly observable in the transverse bark, that of the pear and apple being very thin and delicate, that of the cherry tree immensely strong: but in the root there is no sensible difference.

If we could conceive that the earth possessed any power of action, in sending particular juices to certain plants, it would not be unphilosophic to suppose, that this power, like that in every part of nature where power of action resides, might be improved by habit. And if the plant and earth accomodate themselves to one another, as a plant certainly accommodates itself in some measure to the climate, we would conclude, that changing crops were, *caeteris paribus*, a disadvantage.

We cannot leave this subject, without taking notice of an opinion of Mr Forsyth, who seems to divide the difference, making the roots perform half the work, and the graft the other half. In treating of grafting, he says, " Mr Bradley, on occasion of some observations by Agricola, suggests something new on this head. The stock grafted on, he thinks, is only to be considered as a fund of vegetable matter, which is to be filtrated through the scion," &c. This, certainly, is a truly philosophic idea. Mr Forsyth says, " In prosecution of (he should have said, opposition to) the view of that ingenious author, *we add*, that the natural juices of the earth by secretion and

comminution, in passing through the roots, &c., before they arrive at the scion, must doubtless arrive there half elaborated and concocted, and so, disposed for a more easy, plentiful, and perfect assimilation and nutrition; whence, the scion must necessarily grow, and thrive better and faster, than if it were put immediately in the ground, there to live on coarser diet, and harder of digestion!" This is certainly an addition to Mr Bradley's opinion, which Mr Bradley himself could not have thought of.

The roots *half secrete, and half concoct* the juices for any graft that is to be put upon them! Are we to suppose that the roots know what graft is to be put upon the stock? It is surely easy to understand how a scion, put upon a stock, should grow faster than if it were put immediately into the ground, without supposing that the juices were half secreted by the roots; because the stock has all its roots fixed in the ground, and in the very act of drawing nourishment; whereas, if a scion, or young plant, is put immediately into the ground, it is a considerable time before it can fix its roots, and send out capillary fibres to

collect nourishment; and, agreeable to this, a scion, or a natural shoot, upon a large tree, grows faster than upon a small one; for why? —because the large tree has more roots than the small one: but we cannot conceive that the roots of the large tree *half concoct*, or *whole concoct*, the juices, more than the roots of the small one.

We have made a few observations on the structure and physiology of trees, and pointed out some of the most essential differences between the animal and vegetable; we now come to shew the most striking analogies.

As every person is directly or indirectly concerned in the vegetable, and directly in the animal economy, we hope it will not be unacceptable to any of our readers, to enter a little into the analogy between the two systems; especially as we conceive it will throw mutual light on both, and, at the same time, assist us in laying aside the prejudices of custom and wrong education.

As the organization of the vegetable is so much more simple than that of the animal, so much fewer are its functions, and so much fewer its diseases.

To understand disease, it is necessary to know what constitutes health.

Health we define to be an equal proportional strength and power of all the solids, and, consequently, an equal proportional distribution of all the fluids. Disease, then, will be any defect or loss of this equality of power: the first may arise from original conformation; the last, from the operation of external agents. From this cause, too, we can see how the vegetable is subject to fewer diseases than the animal, especially the human species; for I believe vegetables never take up any thing for their food, but what is salutary. The brute creation, too, are very careful in choosing their food, and seldom err but when deceived by mixture; and even here they shew great sagacity in separating what is fit, from what is unfit for their health, if a separation can be made; and when it cannot, they will not taste of the mixture. But man, regardless of his health,

pays no regard to either quantity or quality: he eats when he is not hungry, and drinks when he is not thirsty, of substances noxious to his body, which induce diseases unknown to the brute and vegetable.

We define all disease, in both the animal and vegetable world, a *want or loss of equilibrium;** and we consider all the different diseases in both, only varieties; for, we must confess, we never found the classification of orders, genera, and species, &c. of any benefit in the *practice* of either the one or the other.

The more complex organization, and greater variety of functions in the animal, render it subject to a greater variety of diseases than the vegetable. But, from this very cause, those diseases which are common to both, are oftener fatal to the vegetable than to the animal. For, in the animal, when the balance is lost by any of the organs being injured, or their functions impeded, their office is supplied by other organs, till nature restore the balance, and

* This definition may be applied to the moral, as well as the natural world.

the fluids again go on in their proper channels. If nature fail in restoring the balance, then another variety of disease will take place, and the organs on which the office of those injured had fallen, will suffer; but the vegetable having no other organs to supply the place of those injured, the original disease must oftener become serious and fatal.

Thus in inflammation, which we reckon a disease common to animals and to trees, especially fruit trees. Perhaps inflammation may not be thought a proper term applied to vegetables, but I have the best of all apologies for using it, i. e. I have no better at present; and we believe, had not custom familiarized us to it, we would not have thought it more proper or expressive, when applied to the animal, than to the vegetable When the motion of the blood is impeded in any part of the animal body, it will be returned back by the veins, and the member be supplied by the lateral branches of the arteries, till nature either restore the injured part to its former power, or dilate the lateral vessels to supply the defect: but as the tree has no returning vessels; at least, as the sap of the tree is never advancing

and retreating at the same time, like the blood in the animal body, the same quantity of sap will fall upon a diseased or weak part, which falls upon it in a sound state, without any relief of return, which will unavoidably increase the disease.

If the sap descended, we believe that this disease would *as seldom* end in canker in the tree, as it does in gangrene in the animal.

The only advantage which the tree has, is from the slower motion of the sap, which allows it to ascend and spread over the tree, by the oblique fibres of the alburnum, and the edges of the bark, if any is left sound to adhere to the wood, and preserve a passage for the sap on the opposite side.

When perspiration is stopped or checked in the animal, the matter is carried off by other outlets till perspiration is restored. From this cause a great variety of diseases arise, which will be as the difficulty to restore perspiration, and the inaptitude of the organs, on which the perspirable matter falls, to perform that office. But the tree having no variety of organs or out-

lets, there can arise no variety of disease; but, from that cause, the original disease will be more increased.

We might be more particular on this subject, but we consider what has been said, sufficient to shew that disease, common to animals and vegetables, is more fatal to the vegetable than to the animal; and, that the diseases of the vegetable are fewer.

Inflammation, or an unequal distribution of fluids in the animal, is a disease common to the vegetable, and arises from the same cause, viz. an unequal power of the solids which transmit these fluids.

This power, in the animal, is a power of action of the vessels which carry on the circulation. In the vegetable, it is merely a power of resistance, of that vessel or sides of the canal, where the sap ascends to nourish the tree, that is, the bark.

The inequality of power may arise in both the animal and vegetable, in two ways;

1st, By original conformation, the causes of which I believe will ever remain a secret.

We are sensible, however, that there can be no effect without a cause; but these causes operate at such an early period of the existence or formation of the body, and are so minute, that it is beyond human power to investigate them. So the *action* of one body upon another, which we do not understand, we call *chemical*, when it is palpable to our senses, we call it *mechanical;* but experience has taught us to believe, that the chain of cause and effect may be still traced farther back than it yet has been.

2dly, By the action of external agents: thus, if the power of any particular part of these organs, by which the fluids are transmitted through the system, is diminished or weakened by injury, while the power of the other parts remains undiminished; and, more especially, if this power is increased, or a greater quantity of fluids is thrown into the system, at the same time, an undue quantity will be thrown upon the injured part, and inflammation with its consequences follow.

Hence it will not be difficult to understand, how the canker appears on the young and tender shoots, while the trunk and larger branches are free; because, from age and exposure to the weather, the bark on them is thicker, has become hard and rigid, and the resistance greater than on these young and tender shoots. This too will explain how those trees which grow freely are more subject to canker, than those which are languid; for their vigorous growth shews a greater influx of fluids or nourishment; and it will be found, on examination, that these diseased or cankered trees have generally as healthy roots, and as many capillary, and often more than the most healthy tree; and these capillary roots nearer the bulb, frequently proceeding immediately from it.

This disease in fruit-trees, called canker, can as easily be traced through all its stages, as inflammation in the animal.

First of all, we observe the sap bursting out, like sweat or dew, on the external part of the bark, soon after corroding it, and forming a ragged substance. The inmost bark, however,

is often preserved, a new longitudinal bark is generated, the diseased part is thrown off, and no other consequence follows, the motion of the sap goes on as usual; this we would call *resolution*.

Sometimes the disease goes a little farther: the whole bark on one side is destroyed; but the sound separating from the diseased, its edges adhere to the wood, it preserves a passage for the sap on the opposite side, and saves the tree or branch: this may be compared to *suppuration*. We have to observe here, that this seldom or never takes place, when the tree is much bark-bound, but when the tree is *not* bark-bound, it seldom or never fails.

As inflammation in animals and vegetables arises from similar causes, so the terminations in each are similar. But these differ much in regard to frequency,—in the animal more frequently terminating by resolution and suppuration; in the vegetable, more frequently in gangrene or canker: the reason of this has already been shewn.

From what has been premised, it is easy to see how a tree is to be relieved, and the balance preserved or restored; by taking off the hard and rigid bark. In the animal it cannot be restored in this way, but it is restored by diminishing the quantity of blood, and so relieving the whole sanguiferous system.

In this case the vegetable must have greatly the advantage; for, in the animal, we deprive the body of a part of that nourishment which is to support it; in the vegetable we give it more: and we actually find, that after the loss of blood it is some time before the animal recover its vigour; but a tree, after losing the external bark, instantly becomes more vigorous than before.

I know it has been reckoned a bold and hardy practice, to take the bark off a tree to give or preserve health; nay, it has been called downright madness by professional men. But we believe it would be reckoned no less bold and hardy, to take the blood out of a man, when first practised, to preserve health, than to take the bark off a tree for the same purpose.

I do not know the man who first practised blood-letting; but I am sure he had not heard, or believed in the doctrines of inflammation, taught in the great school of physic in the north; for if he had, he would never have thought of such a remedy. And had I ever believed that an increased power of the vessels, in any particular part, produced an accumulation of fluids there, I never would have thought of diminishing the power of the other parts, to preserve the balance; I would rather have thought of increasing it, to *determine* the *circulation* to the extremities, their grand indication of cure in inflammation; but I saw the extremities, by the sap bursting out, were already overloaded, which I conceived owing to the weaker power of resistance in that part; this power I could not increase, but I saw the balance might be restored, and the distribution of the sap equalized, by diminishing the power of resistance in the other parts of the tree, that was, taking off the strong and rigid bark.

We use power of resistance when applied to the vegetable, because we are not certain if a tree possess any power of action; but this does not do away the justness of the analogy;

for there cannot exist a power of action, without a power of resistance, though a power of resistance may exist without a power of action; and where the power of resistance is gone, the power of action must be gone before it.

There is another case of analogy to be taken notice of, that is, the *vis a tergo*. This power in the animal, i. e. the action of the heart, is very evident and strong; and if this power is increased at the same time that the power of any particular part is diminished, inflammation will be more serious.

A *vis a tergo* is not so evident in the vegetable, but, certainly, is not, and cannot be awanting. If, then, this power is increased, while that of any other part of the tree is diminished, or is weaker than that of the rest of the tree, a greater quantity of sap will be thrown upon that part, and the disease increased. This power cannot be increased in the vegetable, as in the animal, by the action of the muscles, affections of the nerves, &c. &c. by liquors thrown into the stomach, and which act suddenly; but it is certainly increased by a greater number of capillary roots, drawing a

greater quantity of sap; and if a greater quantity of sap pass to the tree in the same time, the motion must be accelerated; but, although the motion is not at all accelerated, a greater quantity of sap will produce similar effects, though less in degree. This shews how transplanting a tree checks its disposition to canker, because, in transplanting, a great number of the capillary roots are broken off; but this can only be a temporary relief, for, in a few years, it will acquire more capillary roots than it had before. Digging round the tree, cutting off a number of the capillary roots, particularly those next the bulb, and leaving it exposed to the weather, to prevent the production of new ones, will have a better effect, without stopping the growth of the tree, and running the risk of killing it altogether. From this, too, it is easy to see how a great crop of fruit checks the canker, because it consumes a great quantity of that sap, which would otherwise have broken out upon the young and tender branches.

We may observe here, that when a tree languishes from a paucity of capillary roots, it may be revived by cutting off a few of the

larger roots, digging round the tree and opening the soil, to allow the new capillary roots to shoot out, and collect nourishment from the earth. For it is to be observed, that when a tree first grows from the seed, it sends down a straight root, apparently smooth, while it receives nourishment from the seed; but soon after, when it requires nourishment from the earth, the straight root sends off a number of capillary roots. The straight root seldom descends far, when it meets with some obstruction, as stones, clods, &c. which turn it aside. Interrupted in its progress, it divides, and subdivides into a great number, each sending out numerous capillary roots. The first capillary roots, increasing in size, follow the same rule; so that the tree, in a short time, is amply supplied with what it requires from the earth. A tree follows the same rule, from the bulb downwards, that it does upwards, as the tree advances in age and size: the trunk and large branches gradually lose the small lateral branches; so the large roots gradually lose the capillary, and retain only those at the extremities, which sometimes run into the cold barren subsoil; s that the tree annot receive sufficient nourishment. In this case, we conceive

it will be of material service to the tree, to cut off a number of the large roots, before they enter the subsoil, and cover them over, that new ones may be produced in the soil. We must, however, observe, that there is much more danger from many roots ending in the soil, than from a few running into the barren subsoil; for we cannot accede to the common opinion, that a root or two, running into a cold or barren subsoil, can much injure the tree, or render it barren, far less promote the canker; for the promoting cause of the canker is not want of sap or nourishment from the earth, but too much drawn by the great number of capillary roots in the soil, which neither the bark, rendered rigid by the cold, can admit, nor the influence of the atmosphere in this climate convert into wood or fruit; which, therefore, breaks out in any part of the tree, where there is least resistance. *

* Query, May not this be the cause, why the pear tree is less subject to canker, and longer lived than the apple tree?—The roots of the pear tree running deeper into the ground than those of the apple tree. If the opinion commonly entertained, were just, the reverse might be expected.

In this climate, we observe too much sap often produce inflammation in the human frame, and break out like canker in the face, where the bark is thinnest and least protected.

When all the roots, or greatest part of them, run into a barren subsoil, and leave few, or no capillary roots in the fertile soil, the tree must be barren from want of nourishment. It is, however, to be observed, that a hard barren subsoil is oftener hurtful to the tree, by returning the roots into the rich soil, and giving it too much, than by allowing them to enter, and giving it too little nourishment. We cannot, therefore, approve of a practice, frequently adopted, of planting upon slabs. In short, we are of opinion that a tree may be barren, but will not canker from want of nourishment. As the health of a tree depends upon the balance between the quantity of sap which the roots draw from the earth, and the capacity of the trunk and branches to receive it; as the roots increase, while the branches decay, and the stricture of the bark continues,—this balance must be lost, and disease ensue. Hence may be seen the error of the common injudicious manner of pruning.—But, when the tree passes

its acme, the roots cease to increase, and the bark rends from root to top. This is the reason why old trees bear better than young ones, and not from the stoppage of a *descending sap*.

Where the power of the atmosphere predominates over that of the earth, which is very rare in this cold climate, pruning to a certain extent may be necessary; but the cure will generally become worse than the disease, because, wherever a branch is cut off, the tree there commonly sends out several more.—The proper cure, therefore, in this case, will be to cut off some of the large roots, drain the ground, if necessary, cultivate the soil, and cover up the roots immediately with fine rich mould, that they may quickly produce capillary roots; the pruning, however, may still be of service till these are produced.

In a rich, dry, and open soil, and a cold climate, a tree can scarcely have too many branches and leaves.

When the large boughs had lost all the small lateral branches, and retained no leaves but

at the extremities, pruning became necessary, though it seems not to have been known how; and no doubt might sometimes be of service, by producing young shoots with leaves, to give the tree more benefit from the atmosphere. This, we *now* consider to be wholly unnecessary, and even hurtful, as abundance of young shoots with leaves can be acquired by peeling and annular barking, while the old are preserved.—I say *hurtful*, because the tree must suffer considerably, by being bereaved of those organs which convey the influence of the atmosphere, before new ones are produced.

To sum up the whole, the sap ascends, and the tree is nourished from the earth solely by capillary attraction. The sap is first drawn from the earth by the capillary roots, and is by them conveyed into the wood of the large roots, with which they communicate, or rather of whose fibres they are a continuation; for, although the roots shoot from the bark, and never from the wood alone, and require the whole bark for their production, they have, like the branches, their origin in the wood. The tree is nourished from the at-

mosphere in a similar manner; for we find the leaves themselves have all capillary appendages, and where the tree has not what we commonly call leaves, it is provided with capillary points or prickles; but we cannot understand what is meant by roots, &c. *imbibing* and *absorbing* sap by pores, as if they were like leeches sucking blood, or hens drinking water. If they did drink it in by pores, we can see no occasion for the roots, and other appendages of a tree, becoming invisibly small; a few pores on a large root, or branch, might do all the business. We can easily conceive how the moisture from the atmosphere is taken up by the tree *; we see the dew hanging upon the capillae, or down of the leaves, &c.—We know how heat operates by relaxing the solids, and rarefying the fluids. The manner in which light operates on the vegetable, is yet a secret, but we have reason to think that it acts on every part of the tree, and particularly on the fluids.

* A question will occur, Whether the moisture from the atmosphere is generally most beneficial, or hurtful to the tree? We conceive that too much moisture in the atmosphere may be as hurtful as too much sap in the ground.

It is light which gives colour and flavour to vegetables; for, though vegetables will grow without light, they do not acquire colour or flavour, but remain white and insipid. The cause of the green colour of vegetables has been a subject of much inquiry among botanists.—Wildenow says, when phlogiston prevailed, it was easily accounted for, because it was referred to that principle. If we think we understand any thing by such terms, it is as easily explained *now* by referring it to hydrogen and carbon. As colour is not in the body, but a capacity to reflect certain rays only, it must depend upon the particular texture or fabric of the reflecting body; but, how light itself should produce this peculiar fabric, we do not understand.

I am now perfectly satisfied, from observation and experience, that the cause of the canker, *is the loss of balance* between the powers of the earth and atmosphere; that this balance generally is, as may be expected in this cold climate, in favour of the earth: the prevention and cure, therefore, must be to preserve and restore the balance; which is done by taking off the thick rigid bark, and

so exposing the sap more to the influence of the atmosphere, and likewise equalizing its distribution on the tree.—If the peeling should not prove a complete cure, which may happen in a very rich and open soil, it needs only to be assisted by cutting off a few of the capillary roots, especially those next the bulb. By these means, we are warranted, from both reason and experience, to conclude that the canker may be prevented and cured, let the tree and soil be what they will.

We have not been able to discover any other disease which fruit trees are subject to, but what may be referred to the causes already taken notice of, and removed by the same methods of cure. The parasitical plants, moss and lichen, are symptoms of a continued constriction of the bark, and consequent languishing state of the tree, occasioned by a poor, wet, uncultivated soil. The bark of every tree is rendered rigid by exposure to the weather. In a rich and cultivated soil the tree sends out a great number of capillary roots, which, producing a stronger influx of sap, overcomes the resistance of the bark, and causes rupture and canker.—In a poor and uncultivated

vated soil, the tree having fewer capillary roots, the influx of the sap is too weak to rupture the bark, which remaining bound, injures the health of the tree, stints its growth, and renders it subject to these parasitical plants, as leanness, from want of food, renders *cattle* subject to vermin; and, it will be found, that *cattle* in this state, are always hide-bound, and trees always bark-bound: and it will further be found, that trees in this state are not subject to canker, and, *vice versa*, that trees subject to *canker* are not subject to moss and lichen. The cure of this disease will, therefore, be to remove the rigid bark, and cultivate the soil.

The misseltoe is scarcely to be found in this part of the island. I know not of a plant but one; I cannot, therefore, say any thing concerning it.

OBSERVATIONS

ON

THE BARRENNESS AND CANKER

OF

FRUIT TREES,

AND THE

MEANS OF PREVENTION AND CURE.

THIS subject, which has attracted so much attention, and undergone so much investigation, seems still involved in great obscurity.

If my observations can throw any light upon it, or tend to lead others to any useful discovery, I shall consider my pains well bestowed, and myself amply rewarded.

The first thing necessary to be done, is to investigate the causes.

The principal of these appear to me, to be *Vermin, Constriction of the Bark, and superabundant Blossom.*

These causes, though they may exist separately, are often combined together, and depend for their continuance and extension on one another.

As the first of these causes, viz. *Vermin,* appears to be the most common and most general, and likewise as the other causes will, in a great measure, be obviated by the mode of treatment I propose for this, I shall begin with it.

When fruit trees grow old, the outer bark cracks and rends into thousands of fissures and crevices, where the vermin deposit their ova, which, coming to life in the spring, attack and destroy first the blossom and leaves of the small short branches on the trunk, and large branches, and soon extend their depredations over the whole tree.

From this will be seen the reason why fruit trees are so often barren near the trunk, and

bear only on the extremities of the branches, and frequently on the upper branches only. For, though the progress of the vermin is very rapid, yet, in fine weather, the fruit on the extremities will get set before they reach it.

From this cause the fruit buds are first destroyed; and, from the constriction of the bark, they are seldom or ever replaced, so that almost the whole branch remains ever after barren.

To destroy these vermin, and prevent their depredations, many means have been suggested, such as washing with different liquids. Perhaps a liquid may be found capable of destroying them, and it is not unlikely that plain water may do it; but of this I have no experience; I only make the supposition from always finding their ova in parts of the tree most sheltered from the rain, that is, the inclined side of the trunk, and under side of the horizontal and pendent branches. But the difficulty of application seems insurmountable, as well as the effect uncertain. The ova of these insects are generally laid so deep and secure in the fissures and crevices, and so completely

covered by the bark, that it is impossible to make any liquid reach them.

Smoaking, tying hair-ropes, &c. round the trees, laying certain substances upon the ground, about the root of the tree, are not worth taking notice of.

As the ova of these insects are lodged in the fissures and crevices of the outer bark, the means I propose to destroy them, is to take off the outer bark* completely from the trunk and large branches, as far, at least, as it is cracked and scaly, by which they will be effectually dislodged, and must inevitably perish when driven from their nidus. If any animal is forced from its nidus prematurely, it will not live. At the same time it will relieve the tree from the constriction of the dry and hardened

* Although I have divided the bark into three distinct parts; in treating of the operation of peeling, I have used the words *outer* and inner bark, for the purpose of avoiding circumlocution, because, in performing this operation, sometimes more and sometimes less of the longitudinal or middle bark is taken off. By *outer bark*, then, I mean not only the transverse, but also a part of the longitudinal. By *barking*, I mean taking off the whole bark to the wood.

bark which injures its health, and renders it more subject to the attack of vermin; for it is observed, that the vermin more readily prey upon the weak and sickly plant, than the more healthy and vigorous: hence it is easy to see how these two causes act together, to the injury of the tree and fruit; the one rendering them more subject to the attack of the other, which carries them on to total destruction: and it has been observed, that the vermin are more destructive in a cold than in a warm season, which has made some imagine it more favourable to their production; but this is a mistake; the cold is not directly favourable to the production of vermin, but by causing decay of the vegetable, which either produces or fosters them. We see this in all putrefying animal and vegetable substances. If the vermin have penetrated through the inmost bark, it likewise must be cleared away, and the wood scraped round to the sound inmost bark. To facilitate this operation, the small short branches upon the trunk and large branches ought first to be cut away close to the wood.

It will often happen in young trees, and in older ones where the bark is not cracked by

age, that fissures and crevices will be formed by wounds, by stumps of branches decayed or cut off, by the branches rubbing on one another, and perhaps by diseases not well known; one of which, it is not unlikely, is constriction of the bark; for, where the outer bark was quite smooth, and apparently sound, I have found the inner and inmost bark diseased. In this case, the diseased part must be entirely cut out, to the wood, and carried round till you come at sound inmost bark, as in the case of vermin. If the disease penetrate to the wood, and go all round, in the same circle or parallel, that tree or branch has no chance to live; it ought therefore to be cut off. If, however, any part of the wood is fresh, it may be preserved by putting in a piece of fresh bark, from another part of the tree, or from another tree; or it can be preserved by another substance, such as a piece of linen rag, to conduct the sap till a new bark is generated.

Peeling cannot be of so much service to wall trees, in regard to the vermin, they mostly residing and depositing their ova in the wall, and not in the bark of the tree; but it is of equal service in regard to the constriction.

The proper season for peeling or taking off the outer bark is winter, or early in spring, when the inmost bark adheres firmly to the wood, and is not easily torn off; though it may be done at any season, but requires more caution and dexterity. The instruments I use for this operation are four: Fig. 1. in form of an isosceles triangle; the cutting edge of the base set at an angle of 45°, with the handle about 18 inches long, for taking the bark off the trunks of old trees, with thick rigid bark. Fig. 2. in form of a T; cutting edge set at the same angle, for peeling between straight branches, where fig. 1. cannot be applied. Fig. 3. in form of an L double edged, set at right angles, with the handle, for young trees and small branches. Fig. 4. a drawing knife for the clefts, and cutting out the canker where it has gone deep.

Many objections have been made to this practice, because it is new, and in direct opposition to the opinion of professional men, which will be taken notice of afterwards. A special objection has been stated against the peeling of cherry-trees, "that it will cause them gum;" but this is not founded on either

reason or experience. The effect is quite the reverse; it prevents them gumming, because it removes the constriction, and allows the gum and juices to disperse freely over the tree: whereas, when the tree is bark-bound, the gum and juices cannot disperse over the tree, but must burst out at some wound, crack, or stump of a decayed branch. The peeling of cherry trees, however, requires to be done with a little more caution than that of pear and apple trees; not to cut too deep, nor too late in the season. On the trunks of old cherry trees, the bark is so thick, that it requires little dexterity to avoid danger; and the younger ones and branches may be relieved by taking off the transverse bark only; which is not difficult to do, as it is not perfectly transverse, but spiral, and winds off like yarn from a clue. The operation of taking off the transverse bark, must be performed in summer, when it separates easily from the longitudinal. We see the cherry and other stone fruit, as well as the pear and apple trees, universally burst their bark, and throw off the transverse, which they never regain, and they never bear well till they do so.

Notwithstanding this operation, some vermin may still arise from some part being missed, or they may come from some other quarter, and infest the blossom. In this case, I propose sweeping and beating off the blossom, which not only dislodges immense numbers of the vermin, but deprives them of their receptacles.

In beating, the stroke should be sharp, and twice or thrice repeated on the same branch, because the vermin are not easily dislodged.

I have practised this for seven successive years, and have always increased it, sweeping and beating ruder and ruder every year; and so far from being deterred on account of knocking off the blossom and young fruit, I have on that very account been encouraged to it, both from the produce, and observing that the trees in general have too much blossom. It is not, however, to be done to every tree at random, for some trees in some seasons do not require it; this seems to depend on the species of the tree, and the time of blossom. If the time of blossom is before or after the season of the vermin, (for they too have their season,) the fruit may escape; hence it happens, that

sometimes the early, sometimes the late, and sometimes the intermediate, is the best crop. The same thing may happen from the weather; but this we cannot remedy; and it certainly would be improper to sweep a tree of spare blossom, not infested. There is much less danger of destroying the sound fruit by sweeping and beating, than could *a priori* be imagined: the diseased, losing its hold, falls easier to the brush or stroke.

The operation of sweeping and beating should be begun as soon as any symptoms of vermin appear; that is, the curling of the blossom and leaves near the trunk and large branches, and should be continued every day, or every other day, till the fruit is *fairly* set, or the season of the vermin past. I say *fairly* set, because it often happens that the fruit is destroyed, and falls off, after it is apparently set, and thus deceives the husbandman, and blasts his hopes.

With regard to wall trees, they cannot so well be beat, but they can be easily swept. It is not my object to take notice of different kinds of walls, but I believe the best will

have crevices, where the vermin deposit their ova; it will therefore be necessary to sweep the wall carefully, and completely before the blossom opens; which will in a great measure prevent their depredations. If, notwithstanding, they attack the blossom, it likewise must be swept off. The use of sweeping, so far as relates to the vermin, will in a great measure be superseded by the practice of peeling.

The next cause is constriction of the bark. This appears to be a more frequent disease, and more dangerous than is commonly imagined. It is indicated by the unequal growth of the tree, in all parts, and most commonly between the stock and graft: the choice of stocks, therefore, will be, such as grow most equally with the grafts to be put upon them; by the tree swelling more where the bark has been cut, or torn off by accident; by the canker, indurations, contractions, and rotting of the bark appearing in different parts of the tree; by the bark rending of its own accord; by the inner bark rending after the outer bark has been taken off, frequently in the very instant, and often not stopping at

the peeled part, but running a great way above, bursting both inner and outer bark. This completely shows that the disease rests in the outer bark.

In this case a longitudinal incision, or a partial peeling, may prove a cure; but it is more certain and complete to peel all round, from the surface of the earth, or rather a little below it, where the bark is soft and yielding, or as far as the bark is observed to rend and exfoliate by nature, but no farther. (For we have already observed, that the roots and bulb do not attempt an exfoliation by nature; a plain indication that it should not be taken off. I have likewise put this to the test, and found, that taking even the external bark off the bulb, effectually kills the tree. To know this may be of service where it is wanted to clear the ground of forest trees, but it cannot kill them, if large, for many years, without cutting through both bark and alburnum of the trunk) The whole trunk, and larger branches as far as the bark, will admit of division.

If the bark bound the tree like a hoop or cord, by being fixed only at the two ends, a

longitudinal incision would be a complete cure; but as the bark is fixed all round, such a cure must be very incomplete. It may be of considerable service on cherry trees, where the stricture depends chiefly on the transverse bark, which, being more lightly attached to the longitudinal than that of pear and apple trees, when cut, sometimes separates itself all round. We can scarcely, however, in any case approve of a longitudinal incision, because it is almost impossible to make it, without cutting the periligneum and wounding the wood; besides, it is apt to spoil the shape of the tree, by making it grow from that round form, which is natural to it. This disease, or rather cause of diseases, is of the most serious nature, because it always increases itself. The bark, losing its health along with that of the tree, becomes tougher, which makes the stricture still stronger. The stricture sometimes goes to such a degree, that the great capillary canal between the bark and wood is completely shut up, by the inmost bark clinging so firm and close to the alburnum, as to stop all motion of the sap in that channel; in consequence the tree languishes and frequently dies. This is what is called bark-binding, the

tree is said to be bark-bound. But, although every tree is less or more bark-bound, it is not commonly thought so, till it arrive at this degree.

It may perhaps be thought necessary I should inform at what age, that is, the earliest period, the trees should be peeled. It is difficult to fix a particular date for different species, varieties, soils, and situations; some species and varieties growing faster than others, and all growing faster or slower, according to the soil and situation. It must therefore be regulated by the symptoms of constriction before mentioned, or as soon as the bark will admit of division. As the tree advances in age, the bark thickens and hardens; the peeling therefore must be carried further up every year.

The practice of grafting shews that a stricture takes place very early; for I believe it will seldom succeed where the graft is more than one year old; and as it is better preventing diseases than curing them, it may be proper to remove the outer bark before any of these symptoms appear; I have accordingly

done so to a number of trees, (pear and apple), of two years old, which have both produced fruit, and grown well to the wood.

In very young trees, a mere scraping, or taking off the transverse bark will be sufficient, and have wonderful effect in promoting the growth of the wood; but ought not to be done, till the month of March, when the sap has begun to be in motion to form a new bark; because, if it is done much earlier, the inmost bark and alburnum, long exposed to severe weather, may be dried and contracted, so as to become impervious to the sap.

I now make it a regular practice to peel, or take the transverse bark off every tree I have, at two years old, that is, the second year from the nursery; and find that it both promotes the growth of the tree, and brings it sooner into bearing.

The last cause I have to take notice of, is superabundant blossom. This cause operates in two ways in rendering the tree barren; by affording more receptacles and lodging for the vermin; and by requiring more nourishment

than the tree can give, so that the fruit either perishes for want of support, or is destroyed by the increase of the vermin, occasioned by the decay of the blossom. For it is observable, that, in this case, when the fruit sets *unequally*, there is some chance of a tolerable crop; and if this did not often happen, the blossom being generally so abundant, I am of opinion we seldom would have any fruit; but where it sets equally, there is little or no chance. The reason of this appears to be, that, when some get the start of others, they draw the nourishment to themselves; in consequence, the others quickly die, by which more support is given to the living: but when they all partake equally, the whole nourishment is exhausted, and the whole fruit perishes. This may be exemplified by supposing a ship at sea with one hundred men, and one month's provisions, but by stress of weather she is driven out of her course, and they find it will be two months before they can reach port. It is clear, that, by throwing fifty men overboard, fifty lives would be saved; because one month's provisions for one hundred men, will serve fifty men two months. In this case it might be reckoned cruel, and the men

might be put on short allowance; but we cannot apply this cruelty to trees, and we do not yet know of any method of putting them on short allowance; and if we did, it is not likely they would thrive; for we find that even other animals cannot suffer equal privations and vicissitudes with man: besides, where is the port they are to get supply? The tree, therefore, ought to be relieved early, by destroying a part of the fruit.

As I do not know what this superabundant blossom is owing to, (but it appears to be a very general, if not universal law of nature, to provide for loss. This is observable in the animal world, as well as the vegetable; and though we cannot understand the reason, the fact is certain) so I cannot propose a preventative: but the indications of cure will be, to diminish the quantity of fruit, by beating it off when in blossom, and assisting the powers of the atmosphere, by peeling and annular barking.

It is a common practice among gardeners to cut off a number of the branches, because, they say, the tree has too much wood; but I

never could learn from them the meaning of this phrase. It is true they say, it is because the tree does not bear fruit, but they do not inform us how the quantity of wood should prevent the tree from bearing fruit.

How far this practice has succeeded with them I know not, nor do I know whether they have made a distinction between trees of a spare and profuse blossom; but I know that I have a number of trees very thick of wood, which bear very great crops; but all these have a very spare blossom: and I likewise know, that it is of advantage to the crop in this climate, where the fruit is so often destroyed by the inclemency of the weather, for a tree to be thick of wood; for I have often observed the fruit of a thick-wooded tree destroyed on that point of the compass whence the storm proceeded, and preserved on the opposite side, when that of the thin-wooded tree was destroyed altogether. Besides, if the tree grow in a rich soil, the greater quantity of wood will certainly check the disposition to canker, because it will consume, or take up a great part of the sap, which would have been more than the bark could admit of, and con-

sequently have broken out and produced that disease. And, we believe, it will rarely happen in a cold climate like this, that a tree will have too many branches: for, the more branches, the more leaves to convey the influence of the atmosphere to produce wood, and more particularly fruit, which requires more of that influence (14); when a number of the branches are cut off, more sap will be thrown upon those which remain, the balance will be farther lost, and the canker promoted.

These observations, without any comment, were given into the Caledonian Horticultural Society, on the 1st September, 1812, to be read at their meeting, on the 8th of that month, when the author was present, to have given any explanation that might have been required, as far as he was able; and that any of the members of that Society might have an opportunity of seeing the effects of the operation, when the fruit was upon the trees. As that was not done, for reasons best known to themselves *,

* All that I have been able to learn officially, the Secretary informed in writing, which I have now by me; " first, that they had not time to read them for other business; and, afterwards, that he had forgot them among some pa-

and fearing it might share the same fate, if given to any other particular society, he resolved to give it to the world at large, where he still had hopes it had a chance to meet with some more friendly; and, though a *stranger*, might be taken in. But, as in this case, he could not be present with every one into whose hands it might come, it became necessary to enter into some explanation.

As many inquiries are made how I was led to this practice, I find it necessary to give some account of it: I had two objects in view; first, that of destroying the vermin; second, relieving the tree from the stricture of the bark. I was led to the first, by a common saying I had

pers of the Society." No doubt, from the pressure of business, in carrying papers of great importance to the meeting that day, which were just two; one, where the author informed the Society, that he had good sea cale, but not a word how he had raised it; the other, a letter from a gentleman in London, to the President, informing him, that he had very good wine of his own making, and if he came to London he might taste it; but not a word how the wine was made, or of what. If the Secretary will look into his *fasciculus* of that date (8th September, 1812,) he will find the above statement correct.

frequently heard, "that May mists were injurious to the fruit." As I never either admit or reject a common opinion without evidence, I set about satisfying myself by observation, when I found it in some measure just. The next thing that occurred to me was, in what manner it became injurious.

Upon examining the blossom, I found a small worm in almost every one, which had not shed off, as in dry windy weather, but had curled together, and formed a nidus for the vermin; not but the vermin settling in the blossom will produce this effect, but moist weather is certainly more favourable for it.

I next inquired whence the vermin proceeded. By observing that the blossom nearest the trunk and large branches was first attacked, I concluded that the vermin came from the tree itself. I was farther confirmed in this opinion, by observing that the old trees were more infested than the young, and that all the trees were first and most infested nearest the root, where the bark was most cracked and rent.

In putting it to the test, I found it put beyond all manner of doubt: for, in performing the operation of peeling, I discovered thousands of the ova of these insects, which, as appears by a microscope, are a beautiful transparent globe, perhaps the most perfect in nature; and I found them generally so securely lodged under the outer bark, sometimes in the inner and inmost, and even into the wood, that I saw no possible means of destroying them, but by taking off the outer bark, and even the inmost, and part of the wood, where they had penetrated so far. The only obstacle that now presented itself was, the danger of killing the tree, and thus rendering the cure worse than the disease. This, however, I considered as nothing but a common prejudice, which required nothing but courage to oppose, because I had every encouragement nature could hold out to me. I had long observed, that the tree was nourished principally by the juices flowing between the bark and wood.

Experiments have been made in different countries to ascertain how trees were nourished, and received their increment; but none of these, so far as I know, were conclusive, or

could possibly be so. These experiments were, barking the trees; by which it was found that the trees all died in three years after. But this is so far from warranting their conclusion, (that the trees are nourished solely from the bark, and received their increment by the periligneum being every year converted into, and consolidated with, the rest of the wood,) that it sets it completely aside; because, if the trees had been nourished solely by the bark, they could not have lived three years; and, that they do not receive their increment in the above manner, requires no experiment to determine; for every body knows that the trees acquire their increment in that season of the year when the periligneum is separated from the wood by the sap. Besides, nothing can be more evident, than that the wood is possessed of sap channels, or canals. This can be shown by a very simple experiment: take a piece of a branch, or the like, bark it clean, and put one end into the fire; these canals being contracted at that end, and the sap rarified by the heat, will be seen to pass off at the other end in the form of steam, or fluid, according to the density of the wood. And there are some, as the cane, which have

these canals so large, that water will readily pass through them. So that, all that their experiments could determine was, that the bark is necessary to the life and growth of the tree. There can be no doubt, however, that the tree receives its increment chiefly from the juices flowing between the wood and periligneum; for we observe that a new ring, or stratum of wood is added every year to the circumference of the old wood: how this is done, is more difficult to understand; but we know that solids are formed from water and the finest fluids, by a deposition of minute particles, as in petrefaction and ossification; and it is highly probable that the wood is formed in the same manner, the old wood serving as a nucleus.

I had observed the bark crack and rend in a thousand places, which I could not conceive to be any thing but an effort of nature to throw off an incumbrance, and required assistance.

I observed that, where she had succeeded, there was a fresh, healthy bark below, and the tree or branch healthy: but where she had failed, the outer bark stuck into the inner like

a dry hardened scab in the animal body, till by its pressure it had stopt the motion of the sap, destroyed the inmost bark, and materially injured the health of the tree or branch; and where it went all round, killed it entirely. I had frequently observed a very small portion of the inmost bark, alone, preserve a tree or large branch alive and healthy. I observed that the transverse bark was always, sooner or later, destroyed by nature, and never again replaced.

I observed the outer part of the bark had lost all organization, and could be of no service to the tree. And observing further, that when this lifeless bark was taken off, the bark below always rending of its own accord, shewed that the tree needed further relief, and required a part of the *living bark* to be taken off. Accordingly, I have found that though taking off the lifeless bark may destroy the vermin, it will not renovate the tree, and cause it send out new wood; for this end, therefore, it is necessary to take off a large portion of the fresh bark, according to its thickness. In very old trees it will require to be taken off to the thickness of an inch, or more; but no rule

can be laid down as to what is to be taken off, but what is to be left on, which may be about one-eighth, or one-tenth inch thick, which will be found sufficient to defend the tree against any weather of this climate.

I knew that universal law of nature, that man is to live by industry, "By the sweat of thy brow shalt thou earn thy food;" and I did not conçeive that we were to have fruit without labour, more than any other crop.

By the indications of constriction before-mentioned, I was led to the practice of peeling in general,—my second object, but which in point of utility ought to be the first.

Since I commenced this practice, many objections have been made to it by professional men. First, the trees were all to be killed by the cold of winter,—"starved to death." Seeing they survived this, they were all to be burnt up with the heat of summer. Finding they withstood this also, they were all to die in three years of a lingering illness. The fifth year is now past, and they are neither dead nor sick, but more healthy than ever. But

this is no doubt owing to the clemency of these amateurs and connoisseurs in horticulture and phlogiston, who were graciously pleased to give them a respite of two years more. As there is a report of their getting a further respite of a year or two more, there is some hope of a final pardon *.

And several trees of great age, with which every means proposed by professional men had been used, but never bore fruit, have, since peeled, produced very good crops. In corroboration of what I here state from my own knowledge, I beg leave to insert a paragraph from a letter I received from a respectable gentleman in the neighbourhood of Glasgow :—

* It is still thought by some, that my trees may yet be starved to death by the cold of winter and spring, or burnt alive by the heat of summer, from want of clothing; but as they have stood the alternate changes of heat and cold for five years, and most of these in as great extreme as commonly known in this climate, we apprehend little danger now when they have got five coats more than I left them, when I first stript them.

LANCEFIELD, near Glasgow, 15th March 1813.

" Mr PATRICK LYON,

" Dear Sir,

" It gives me much pleasure to inform you of an experiment made in imitation of the one with which I saw you engaged, in December, 1811.

" When I came home, I caused a cutler make me an instrument similar to the one you shewed me, for barking your trees; and commenced my operations on an old Scotch Carnock, with a very hard and corrugated bark, which regularly produced plenty of blossom, but seldom or ever any fruit. I began among the small branches near the top, and continued working downwards, destroying in my progress many thousands of insects, with their eggs. Most of the professional men blamed me for spoiling a good tree. In spring it produced a profusion of flowers, which they declared useless, and the last it would ever shed.

In autumn, however, it yielded as much fine fruit as it could possibly carry. The bark is now in a healthy and vigorous state, and the tree has every appearance of bearing a large crop this season.

(Signed) "JAMES HARDIE, Jun."

Another argument has been brought forward against the practice of peeling, "that nature would not have given the bark, had it not been for some useful purpose." This is certainly true, when applied to sound inmost bark, because it is so essential that the tree cannot live without it; as the juices which nourish the tree are carried on between it and the wood: but it is difficult to conceive the use of dry hardened scabs: and though the whole bark may be necessary at an early period to carry on the sap, as it is then very thin and yielding, and cannot much injure the tree by its stricture; yet, at a more advanced period, it seems not only unnecessary, but hurtful.

So the food that is necessary for the young animal, is not only unnecessary, but unfit

for the old. And it may be observed, that the transverse bark, which is the principal cause of almost all the maladies of fruit-trees, is always destroyed by nature, and never replaced. We see the sheep cast their fleece, but so imperfectly, that it becomes a burden to the animal and requires the assistance of the shepherd; and we would consider him a bad groom, who did not comb his horses when they cast their hair.

We do not suppose that nature gives any thing in vain; but we see, as in the transverse bark, and in the blossom, that when she has served her purpose, she throws them aside; and when we observe her too weak, or too tardy, it is our duty to assist her. But the vanity of man makes him think that nothing is of use in nature but what is for his own. He fancies the earth was made for him. The sun and moon were made for him, and the stars are only as so many brass nails to adorn the roof of his carriage. Further, if we are not to venture to take off the bark because nature has given it, we ought not to root out weeds, because nature has given them also; and why destroy the vermin? They too are the gift of

nature. If we were to follow out this mode of reasoning, where would it lead us? Nature could have produced crops without weeds, and fruit without trees. She could have produced the fruits of the earth without tilling and sowing: why not loaves and rolls ready made, and then there would have been no occasion for sowers, reapers, millers, or bakers? Nay, nature could as easily have made man to live without food: but in that state what he would have been we can have no conception. I can give no other reason for these productions of nature, than that they are to make man industrious. The *stricture of the outer bark*, however, which gives rise to the greatest part of the labour on fruit-trees, can easily be explained, without referring to the final cause.

The outer bark forming a greater circle than the inner, would require to expand faster, but is prevented, being rendered more rigid by exposure to the weather, and is burst by the growth of the tree*. But frequently

* If we were to reason, or rather imagine, like the medical tribe, we would not suppose that the bark was burst

before the tree can overcome the resistance of the bark, it is materially injured in its health, and when it fails altogether, dies. It may be observed, from the straps on wall trees, that a very slight stricture checks the growth of a tree or branch, and produces canker. Some explain this disease by a *morbid habit.* Happy Greek and Latin! you can explain any thing to the understanding of the meanest capacity. A *diseased* habit would never do; for then disease would be just disease, canker would be canker, and no more; so would *tantrumbabus* be just *tantrumbabus*. And we are informed that something more than a mere extinction of vegetable life appears to take place in this disease. We are at a loss to conceive what more can take place in either animal or vegetable, than an extinction of life in this world; and we are not inclined to follow the subject farther.

The Caledonian Horticultural Society have offered a premium, *not* for discovering the

by the growth of the tree, but that the *vis medicatrix naturae* brought on a spasm or constriction to remove the constriction.

cause of the canker, but for the best *attempt* to discover it. How they are to determine who comes nearest the mark without hitting it, will appear, we suppose, in their next *fasciculus.*

Half premium for the second best attempt. If the second come more than half way up with the first, he should have more than half premium. Query, What for the ultimatum? Such attempts are certainly laudable; and, although they should end there, and be of no service to any body else, they will serve the *Fasciculus.* *

And it may be observed, that fruit-trees seldom bear well till they burst the bark, and then they are soon after infested by the vermin; so that they never are, at best, but a few years, in what may be called a good bearing state.

A question has been started, whether the vermin is the cause or effect of the canker?

* Fasciculus; a bundle of Nursery-men, Gardeners, Printers, and Doctors.

The vermin certainly is not the general cause of the canker, though I believe they may sometimes produce it topically; nor is the canker the exciting, but only the predisposing cause of the vermin; as is the rending of the bark, wounds, injuries, &c.; and I do not find that these produce even *topical* canker, in a tree not bark-bound. So wounds on the animal body, in good habit, heal up without any bad consequence; whilst, on a bad habit, the slightest scratch often becomes serious, and sometimes fatal.

The *stricture of the bark*, however, must be viewed in a very different light; for it is undoubtedly the general cause of the canker, by not allowing the juices to disperse freely over the tree, which, bursting out at any weak part, form, with the bark, this ragged substance called canker. For we know, that all stagnant animal and vegetable juices, when exposed to the air, are much given to putrefaction, and communicate it to, and promote it in, other bodies. Accordingly, we observe the sap of the tree first breaking out like sweat or dew upon the surface of the bark, soon corroding the outer bark, next communicat-

ing the disease to the *periligneum* and the wood.

Gums, resins, and essential oils, are exceptions to this rule; and, accordingly, I have never observed the canker attack the cherry tree; and am of opinion that it never does, and never can, whatever Mr. Forsyth and others may have said. It is true the cherry tree is subject to the same disease,—an unequal distribution of the fluids, arising from an unequal power of the solids,—as well as the pear and apple tree; but this never terminates in canker, for this plain reason, that the juice of the cherry tree is not of a putrefactive, but rather antiseptic quality. The same rule, we believe, will hold with all gummy, resinous, and gum-resinous trees.

We observe, when the cherry tree is wounded, the bark torn off, or the balance any way lost, the juice exsudes; but soon concretes into gum, and shuts up the wound; but we have never observed the bark and wood rot, as in the pear and apple tree. If the wound is very large, or the bark torn off to great extent, the wood will be dried by the action of the air, so

as to become impervious to the sap, and the tree die from want of nourishment; but we have never observed the tree, to use the common phrase, bleed to death.

Sometimes contractions, indurations, and rotting of the bark, are produced without this ragged appearance, which are equally dangerous, as they are effects of the same cause.

And it will be found that the disposition of the trees to canker, is, *ceteris paribus*, in proportion to the transverse strength or power of the bark, *i. e.* the aggregate power of the transverse bark, and the transverse cohesion of the longitudinal, taken together. So the disposition to canker will be, as the transverse power of the respective barks to the force exerted by the growth of the tree. This force it will be difficult to ascertain; but it cannot be thought irrational to suppose it, under similar circumstances, nearly the same. This seems to be supported by what follows.

The relative powers of the different barks can be ascertained pretty accurately, when it will be found that the trees most given to

canker, and those which continue longest in an apparent healthy state, without bearing, have the strongest bark transversely, and that those which have the weakest bark transversely, are the greatest bearers, and least given to canker.

This both accounts for the canker, and "how full grown fruit-trees, especially some of the finer sort of French pears, which, though apparently in a very healthy and luxuriant condition, are yet in a state of almost total barrenness." For the very cause which, at last, destroys them altogether, preserves them longer in this apparent healthy state, viz. the strength and firmer cohesion of the bark, which continues to stretch longer without bursting, and forming residence for the vermin, than those of weaker cohesion; yet they are really and truly bark-bound, which prevents them receiving that nourishment fit for bearing fruit. And it may be observed, that these trees, though they may continue for a number of years in this apparent healthy state, at last break out into one universal canker.

As the stricture of the bark is the cause of the barrenness and canker of these trees, is it not probable that it is also the cause of their fruit not coming to maturity in this climate? And though we cannot suppose any means can supply the place of climate, yet they may assist, to some degree; hence it is not irrational to conclude, that taking off the outer bark may be a means of maturing these fruits better. I have not had sufficient experience to speak fully on this point; but I certainly had finer fruit of these kinds, than I had been accustomed to see, or that these trees ever produced before they were peeled, and a much greater quantity, though every means hitherto used had been tried; and accordingly we find these trees bear better, and are less given to canker, upon the wall, than on standards. When the thick external bark is taken off, may not the heat and light have more effect on the sap; which will then be more exposed to their influence, in maturing the fruit?

I have made a few trials of the relative strength of different barks. For example, the beurré, (yellow,) an indifferent pear, but a great bearer, and little given to canker; the

French bergamot, a very fine pear, but very shy bearer, frequently continues long in an apparent healthy and luxuriant condition, but almost totally barren. Taking, then, the power of bark of the beurré for 1. that of the French bergamot will be 1.7142 *fere*, or as 7 to 12, almost a duplicate ratio.

But when the transverse bark, on which the stricture chiefly depends, is taken by itself, the difference will be found still greater: thus, taking the power of the transverse bark of the beurré, for 1. that of the French bergamot will be 2.1666, or as 6 to 13; that of the jargonell will be 2.2, or as 5 to 11; that of the muscat, (a tree very much given to canker,) will be 2.8, or 5 to 14; that of the longueville will be 2.8, or as 5 to 14.

Any person may make as many experiments of this kind as he pleases, but we think these sufficient to establish the general principle. Perhaps some species of trees may be more given to canker, in some soils and situations, and other in others; but this can make no alteration either in the rule or practice; and it is believed that those on which the above ex-

periments were made, are much given to canker and barrenness, in every soil and situation, in this climate ; and on several hundreds of trees, of many different kinds, and of all ages, not one bit of canker is to be found, where the outer bark has been taken off, some five years past, some four, &c.

From these observations, no doubt can remain, that the *stricture of the bark* is the cause of the canker, indurations, contractions, rotting, vermin, &c. The radical cure, therefore, will be, to remove the *stricture*, by taking off the outer bark *, which I have found

* I believe very few cases will occur where a proper peeling will not cure the canker; but, if any should occur, which is possible, in a very rich and free soil, it may be assisted by cutting off the capillary roots next the bulb, and exposing it to the air for a considerable time, to prevent the sudden production of new ones. In short, from both reason and experience, we have good ground to believe, that, by peeling, annular barking, transverse incisions of the periligneum, and cutting off the capillary roots, the canker may be cured and prevented, let the tree and soil be what they will. As the canker is not a topical disease, we look upon the method of curing it, proposed and practised by Mr Forsyth and gardeners, cutting out the cankered part,

confirmed by experience; and I have found this practice not only answer all the expectations I had formed of it, but far exceed them. I expected to render the tree more healthy, and I expected to increase the quantity of fruit; but experience has shewn, that it will not only increase the quantity, but also improve the quality; that it will renovate the old trees, and promote the growth of the young; and that it will bring old trees, which before were always barren, and young ones, sooner into a state of bearing. And I have every reason to believe, that it will make the trees bear every year, by converting the wood buds into fruit buds; for almost all those trees, which were peeled five years ago, have had five very abundant crops.

What I had predicted is now verified; these young shoots, which the tree sends out after

and applying the composition, &c., like a surgeon cutting off a man's nose, infected with a certain disease, and applying his plaisters and pledgets, without doing any more; for, though the cankered part may possibly heal up, the disease will certainly and suddenly break out in another part.

being peeled, are now bearing fruit on the whole length of the trunk and larger branches, frequently in the second year, which we believe is very rare in pears and apples, and the old branches bearing along with them.

We must observe here, that it is necessary to peel, or take the transverse bark off these young shoots, for two reasons; to prevent them being seized with the canker; but especially to give the stem strength to support the top, which grows luxuriantly to lateral branches, from receiving so much nourishment from a large trunk. And, however strange it may appear, it is a fact, that I have had instances of these trees bearing fruit on the wood of the current year, and coming to maturity, though late in the season.

When the trees are peeled, they send out numerous young healthy shoots from the trunk and large branches, which will come to bear fruit before the old ones fail *, and thus give

* Fig. 5, is a swan egg pear tree, 100 years old, which has been for several years past in a complete state of decay. The young healthy shoots upon the trunk and large

a constant supply, without the loss of time, as in the common way of cutting down and grafting: whereas unpeeled trees seldom send out young shoots from the trunk and large branches: and when they do, these seldom come to any perfection, but generally die the first winter; because, from the *stricture of the bark*, they do not receive the proper nourishment, and are festered at the root, or offset, by the vermin and rotten bark of the trunk or branch from which they grow.

A curious circumstance attends the operation of peeling: The more decayed and diseased the tree, the sooner and faster it revives, and sends out those shoots.

Thus nature, like a kind and grateful friend, repays us according to the service we have

branches, as far as peeled, not one of which died in winter, and those of the present year, are too numerous to be represented on a superficies. Some of these of the current year measure 3 feet 9 inches in length, and 2½ inches in circumference, and have sent out branches 1 foot 3 inches long. Most of the trees have nearly the same appearance, and making wood at the extremities of the bearing branches.

done her; which, like all services, is in proportion to the distress and need of assistance.

At first, I was at a loss to account for this phenomenon; but reflecting on a well known fact, that the roots of trees are more durable than the trunk and branches, and often remain healthy after these are totally gone, by either accident or old age, I examined a number of trees, which, though young, were in the last stage of decay. I found the roots of these not only healthy, but numerous, most amply provided with capillary roots, many of them immediately proceeding from the bulb, and almost all ending in the rich soil,—few, or none descending into the subsoil. I examined a number of *more healthy* trees growing contiguous to the former, and found the roots equally healthy, but not near so numerous, nor so liberally provided with capillary roots.

At this time, a great number of very much diseased and decayed old fruit trees, of different kinds, growing in a rich, deep, and open soil in the neighbourhood, were rooted out, as being entirely useless. I found the roots

of every one of these, healthy, numerous, and most amply provided with capillary roots. This shews how trees will canker sooner on a rich and open, than on a hard and barren soil: it shews how these trees which grow fast, canker sooner than those which grow slow: it shews how the diseased tree recovers faster than the more healthy: and it shews how the canker is promoted. For, if the quantity of sap, carried into the tree, is greater, which it must be, by the greater number of capillary roots, while the stricture of the bark remains, the disease must be increased; but, if the stricture of the bark is taken off, the greater quantity of sap will revive the tree faster. Thus, the promoting cause of the decay, is the efficient cause of the speedy recovery.

Had the structure of the bark, its connection with the buds, its manner of formation, and particularly that of the wood, been understood and maturely considered, we might have known, *a priori*, that any part of an old tree would have sent out buds, when the outer bark was taken off (15); because the first buds are produced when the bark is thin, and no hard rigid bark to obstruct them; but every

season adding a new layer of bark next the alburnum, removes them farther from the source of nourishment, at the same time that part of the alburnum from which they proceed, getting every year an additional coat of wood laid over it, they are so compressed, and consequently deprived of nourishment, that the buds and branches die and fall off, and the hard rigid bark prevents the production of new ones. The most striking examples are constantly before our eyes, and appear in all trees, especially in some of the forest trees, as the oak, the beech, the fir, &c.; the branches decaying and falling off in regular *succession*, from the root to the top. Accordingly, we find those trees which form the real wood soonest, lose their branches first; and we find *that* part of the branch inclosed in the wood of the alburnum, as hard and compact as the real wood itself, which shews the great degree of compression: but, when these hard rigid coats are taken off, the new alburnum sends out new buds as the former did.

In the common manner of growth in trees, the lateral buds are formed in one season, and expand into shoots the next; but when the

tree is peeled, these new buds are formed and expand into shoots, four and five feet long in one season, and that the first season the peeling is performed; especially if the tree is much decayed; and these shoots themselves frequently send out lateral branches, 12 and 18 inches long the first year.

These shoots may be very useful for grafting and budding, as the trees produce them in such abundance, and very strong, and as young shoots are often very difficult to be found on old trees.

When a tree is cut over, without being peeled, it sends out shoots at the cut only, or at most a few inches below it, because the bark is relaxed only so far; but when the tree is peeled, whether cut over or not, it sends out shoots in every part of the trunk, and larger branches, as far as peeled. If branches are wanted at any particular part of the tree, which often happens on wall trees, to make sure of them, we need only to make a transverse incision of the inmost bark above the part, or annular barking; and we believe it will be found more certain than the insertion of

buds. Another advantage will arise from the peeling of fruit trees. If another variety is wanted, these shoots will be most fit to graft or bud upon, while the old bearing branches, if a good kind, may remain and bear fruit.

Mr Forsyth recommends cutting over the tree, and allowing it to send out young shoots to graft upon, in preference to grafting upon the old stumps; but when the tree is peeled, there is no occasion for cutting it down to make it produce young shoots, because the peeling makes it produce many more than the cutting down does; and if, in any case, this should fail from the peeling not having been so completely done, annular barking will produce young shoots to a certainty, immediately below the incision.

Some have imagined that these shoots from the trunk and large branches of peeled trees, would hurt the growth on the extremities. This, at first sight, appears a rational supposition, but experience has shewn the reverse; for these trees which have sent out thousands of these shoots, have grown more on the ex-

tremities since, than they had done for many years before.

The reason of this appears to be, that, by removing the stricture of the bark, a freer motion and a more equal distribution of the sap is given, to nourish every part; and, accordingly, I have found those trees, sending out innumerable shoots from the trunk and large branches, growing well at the extremities, and bearing fruit abundantly at the same time.

It is said that all efforts which have hitherto been made to propagate healthy trees, of those varieties which have long been in cultivation, have been entirely unsuccessful; that the grafts grow well for two or three years, after which they become cankered and mossy, and always carry the disease of the parent tree along with them. But we are sagaciously informed, "that the grafts will not be affected by any incidental injury; the parent tree may suffer after they have been detached from it." We can scarcely imagine that a person believing in witchcraft and hydrophobia would doubt this fact.

I have not had time or opportunity to know whether the same consequence will follow the young shoots from the trunk and large branches of peeled trees; but as these shoots are themselves healthy, and the trees from which they are taken rendered healthy by the peeling, it is, I think, highly probable that they will continue to grow healthy when grafted upon new stocks.

If this should succeed, those finer varieties which are said to be wearing out, may be preserved.

If we may be allowed to reason from analogy, we have every reason to believe that the offspring of these trees will be healthy; for we know, that, in the animal system, whilst the parent labours under certain diseases, the offspring will be infected; but after the parent is completely free from the disease, the offspring will be as free as if the parent had never laboured under such disease.

If it is true, which I believe cannot be denied, that the roots of fruit trees are more durable than the trunk and branches, we have

every reason to conclude, that these shoots, grafted upon the roots, will be a means of preserving these varieties to a later date than any that has hitherto been adopted, so far as I know; for here we have a double chance: the roots are more durable than the trunk and branches, and grafts taken from the trunk are less subject to canker and decay, than those taken from the bearing branches. Besides, as we conceive that an equal growth of the stock and graft is necessary to the health of the tree, we are more likely to obtain that object in this way, as the stocks are often diseased and stinted when the roots are healthy and free.* Thus, any man who has a few

* I do not know what is in other places, but I can scarcely find a single tree from the nurseries here, the stock of which is perfectly healthy. In taking off the outer bark, I find the bark below discoloured in different places, and evident marks of erosion, which induces me to believe that the health of the tree depends more upon that of the stock than has commonly been imagined. May not grafting and budding on the branches and young shoots of such trees, as the burr-knot, which grow readily by cutting, be a means of propagating more healthy trees, of different varieties? I have tried this method, but it will require time to know the result.

old trees may have as many new ones as he pleases; for the peeling will give him abundance of grafts, and the roots will amply serve him for stocks; for 5 or 6 inches of a root, with capillary, will be sufficient. And it will save the trouble of claying, for they are to be planted with the splicing, two or three inches below the surface of the ground. It will likewise allow longer time for grafting. The grafts should be cut off any time from the end of October to the end of December, but not later. They may be spliced any time during the winter, and planted out when the weather is favourable; or they may be kept covered with earth, and planted in February or March. We have reason to believe, that there are many species of trees, besides their own, whose roots will answer to graft upon; but what kinds will answer best, must be determined by experience, and further observation. In the case of grafting upon roots, the graft and root not only unite, but the graft itself frequently sends out roots.

I have practised two ways of grafting on roots; first, of cutting the root away from the bulb of an old tree, and allowing the far end

to remain in the ground, putting the scion on the end cut from the tree, in the common way of grafting, and laying the earth round the splicing. I found the graft succeed very well in this way; but the transplanting became a very awkward and uncertain operation, for the root frequently ran to a great length without any capillary roots, but at the extremity, which were apt to be broken off. The next way I tried, was cutting the root from the tree, and following it out to the extremity,—cutting it into lengths of six or seven inches, studying always that each cut had a number of capillary roots,—putting a scion on each of these cuts,—and planting them as already taken notice of. A great number of these have failed; but, as a considerable number have done very well, it shews at least, that it is not contrary to the laws of nature: the failure, therefore, must be owing to some other cause. We conceive the principal cause of failure, is the roots not being fixed in the ground, and in the act of drawing nourishment. If, however, it shall be found to be a means of producing more healthy trees, it is worth trying, as one healthy tree is better than ten diseased ones; and, in raising new trees from the seed, it is fifteen or sixteen years be-

fore their quality can be known, and then we have not, perhaps, one in a thousand worth preserving. But why not graft upon the roots of young seedling plants, which have their roots fixed in the ground, and in the act of drawing nourishment? I had none of these to make the experiment on, but intend to try it as soon as I possibly can. And I see no reason why the variety may not be preserved to the end of time as well as that of animals.

So, likewise, we believe that the individual fruit tree may be preserved in a healthy and bearing state much longer than has commonly been imagined; for we have no reason to suppose that those shoots will fade or decay, while the roots remain healthy, and the stricture of the bark taken off: and when the bark again thickens and hardens, so as to obstruct the production of buds, we have reason to presume, that the same operation will produce the same effect; but, in time, the roots must fail, and the tree perish.

These shoots will be very beneficial in re-thickening old trees, which have become so

thin of wood as to afford no protection against the fruit-destroying blasts. They will likewise help to consume what the gardeners call superfluous sap, and by giving the tree more leaves, will give it more benefit from the atmosphere, and so contribute to prevent the canker. We are informed by a late writer, that all the varieties of the apple, which have long been in a state of cultivation, are fast hastening to decay, and can no longer be preserved in a healthy state, by any means that have been tried; nor can healthy trees be propagated from them. We are not inclined to treat this subject in a Hudibrastic style, as some have done; for it is well known, that the diseases of the parent, both in the animal and vegetable, frequently descend to the offspring; and every farmer, and every gardener of common sense, expects a better crop from good and wholesome, than from unwholesome seed: we cannot, however, go the length to believe, that when the parent tree decays and dies, all its offspring will decay and die along with it. Is it not reasonable to suppose, that those trees which are propagated from it in its healthy state, will continue healthy, and live longer

than the parent? And while these are in a state of health, May not healthy trees be propagated from them, *ad infinitum?*—We are at a loss to conceive how long cultivation should produce decay and debility in the apple tree, especially as we are told by the same writer, that it is cultivation only which has improved the apple, and brought it to its present state, from the natural crab. He has left us here entirely in the dark; he has neither informed us of the modes of cultivation, which have improved the crab, nor those which have brought on the decay of the apple. It is true, he has told us that vegetable, as well as animal life, is limited to a certain period. This, however, is true only of the *individual*; for we know of no limits set to the existence of the *species* of either animal or vegetable. Till this is explained, we must say, we are inclined to doubt both facts!

We do not believe, that the crab has become a good apple by cultivation only, nor do we believe that cultivation has brought on the decay of the apple; we do not hesitate to say, that it is *want* of cultivation which has brought on the decay of the apple, and pear also. I

believe the apple has been removed from situation to situation, from soil to soil, the ground cultivated, manured, &c. &c., while the tree itself has been allowed to remain almost in a state of nature, or what has been done to it, has been rather hurtful than beneficial. If man had been removed from situation to situation, from a cottage to a palace, while his hair was allowed to grow like a wild bear, his nails like eagles claws, his face and hands never washed, his whole body crusted over with mud, dirt and scabs, nothing done to him except a limb lopt off now and then; if he had degenerated, would we say, he had long been in a state of cultivation? Nature occasionally presents man with what is good, saying, take care, and preserve it,—" by the sweat of thy brow shalt thou earn thy food,"—it may be long before you get another. We believe that the different species and varieties of fruit and other vegetables, are the productions of nature, by a concurrence of circumstances and process not yet discovered; though the care and attention of man may preserve and improve them. We find this writer using and proposing methods of propagating healthy apple trees; but none of these are from the crab by cultiva-

tion only, nor without the use of an already cultivated kind, and some of these of the kinds which have been *longest* in cultivation. If we were to adopt his own way of reasoning, from analogy of the animal, we would state the same objection to his method of propagating healthy trees, which is by crossing the breed. How far crossing the breed in animals improves the offspring, we are not at present prepared to speak; besides, it is rather foreign to our present purpose. But, surely, if we wish to have a healthy offspring, we would chuse both parents healthy; for if we couple a healthy and an unhealthy parent together, we have, to be sure, some reason to expect that the offspring may be more healthy than the unhealthy; but we have little reason to expect that it will be more healthy than the *healthy* parent; and especially, as he informs us, that the good and *ill* effects which follow the process of crossing the breeds of plants, are perfectly similar to those which have been observed among animals, that the immediate offspring will present a mixture of both characters in nearly an equal proportion. This mode of propagating healthy trees, brings me in mind of a chemist of some note, who invited me to taste his ale, of which he had

two kinds. He wished to have my opinion which I thought best. I gave it. He said I was right, but that he would make an improvement; this was by mixing a bottle of each together. I could not help observing, that I thought it might be an improvement on the worst, but that I was rather at a loss to understand how it was an improvement on the best. If the fine varieties of the apple, which are said to be now wearing out, have been produced from the crab by cultivation, why not propagate from the crab by the same means? and if we have not the *same*, we surely may have as *good varieties* as our *ancestors*.

If such great improvements, as we are told, can be made by crossing the breed in vegetables, it is certainly an unpardonable neglect not to practise it on the more useful vegetables, wheat, barley, &c.

I am aware of an obstacle which will occur to many,—that the bark will again thicken, and become rigid, by exposure to the weather; but this is only the longitudinal, whose cohesion is preserved by the transverse, which, when once destroyed, either by nature or art,

is never again replaced: so that the same degree of stricture can never after take place; nor can the like receptacles be formed for the vermin. The longitudinal bark, when freed of the transverse, always rending freely and exfoliating, leaves no cover. The alburnum and inmost bark, being relieved from the stricture of the outer bark, and consequently growing faster, is the cause of this exfoliation; at all events, as it appears that trees, in general, do not suffer much from the stricture of the bark, till it has acquired five or six coats, the operation will not require to be done oftener than once in five or six years. It is true the bark does not exfoliate altogether completely, and the tree is sometimes covered with a brown or grey powder; but both these are easily taken off, by a mere scraping or a hard brushing.

It is not, however, to be imagined, that any means can be devised to enable the fruit to resist perfectly every possible attack of the weather, or supply the place of climate; but if any means can be discovered to make it stand the storm better, it is doing something. And if we can render the tree more healthy, the blossom will be stronger to resist the at-

tack of the vermin; and if one kind of weather is more favourable to vermin than another, we may, therefore, properly say, that these means defend the tree and blossom against the weather.* But will not a tree, which is strong and healthy, resist the *direct* inclemency of the weather better than one which is weak and sickly? which we consider as a predisponent cause. So the cold wax does not yield to the seal, but, melted, receives the impression from the slightest touch. Not that it is to be imagined that we can remove *completely*, all the causes which destroy fruit; and if we could, it is more than probable it would cost us more labour to destroy the superabundant produce, than to moderate the effects of the destroying causes. Besides, it does not appear, though

* In spring 1812, when all the trees in the country were blasted by a severe storm with frost and snow, it was observed by several gentlemen,—particularly by Sir George Hepburn of Smeaton, who has paid more attention to, and been of more service in improving agriculture and horticulture, than most men in the kingdom, – that my trees had recovered sooner than any they had seen. This, no doubt, must have been owing to the sap being more exposed to the influence of heat and light, when they returned.

we could remove all these causes completely, either proper or necessary so to do. For, as every part of the creation, from the highest planet to the lowest invisible insect, vegetable and atom, seems dependent on another, it cannot be thought absurd to suppose that nature provides for loss in every individual part to support another. If it were otherwise, that beautiful harmony and connection between the parts, which now exists, would be lost. But here we must stop, because we can never trace the chain of cause and effect to the extremity, either above or below, nor understand the prime and moving cause of all things; but if we can trace the cause of good and evil, so far as to enable us to promote the effects of the one, and prevent those of the other, we ought to be satisfied. In this view it becomes a necessary law of nature, that one part of the creation should, to a certain extent, destroy another. So, even the vermin may be necessary to destroy, to a certain extent, the produce of fruit-trees. But when those become too numerous, and too powerful, it is the business of man to preserve the balance; and this seems to be all he has to do, and all he can do—to check the operations

of nature, when too violent, and to support and assist them when too weak; and for this purpose nature has endowed him with superior powers. By destruction, it must be understood I mean only change of form and place; absolute destruction or annihilation is nonsense. " *Omnia mutantur, nihil interit.*"

If trees, like animals, exhale any thing by the surface, noxious to themselves,—as they certainly inhale something salubrious from the atmosphere,—removing the rough, corrugated, dry bark, may be as necessary to their health, in these respects too, as cleanliness is to that of animals.

Query, May not forest trees be peeled with advantage? especially the oak, whose bark is so valuable in manufacture, and whose wood, to the wealth and defence of the nation? but which last is lost, being cruelly cut down for the sake of his bark before he is fit for this service. I had no forest trees to practise upon; but I have as little doubt of the result, as I had of that of fruit-trees, which will be not only to preserve the oak till he is fit for ship-building, but likewise increase the quantity

of both wood and bark; for both increase in proportion to the circumference of the tree. The annual layers of wood and bark are, we believe, *caeteris paribus*, equal in thickness. Therefore, a tree of four feet circumference, will make double the quantity of wood and bark in one year, with one of two feet circumference: but the increase will be still greater; for when the stricture of the bark is taken off, the tree grows faster.

Since I first published my observations on fruit-trees, I have been at some pains in examining the bark of the oak; and find that the tanning principle resides in every part of the bark, when fresh, except the inmost, which is left for the support and growth of the tree. It is likewise to be observed, that the oak ruptures the bark, and attempts an exfoliation, very early by nature; that these half exfoliated flakes lose all the tannin, and are good for nothing in the manufacture of leather; so that, in peeling the oak, there is both a gain and saving.

I know an objection has been stated against peeling the oak,—that the wood growing faster will be less hard and durable. We believe the

reverse will be the case: for when the thick rigid bark is taken off, the sap will be more exposed to the influence of the atmosphere,—the agent which converts the sap into wood. And it will be found, that if a tree is either peeled or barked long before it is cut down, the wood will be specifically heavier, harder and more compact, than when it is cut down with the bark on.

Since publishing these observations, I see that the peeling of trees promoting their growth, has been observed by Mr Knight, on the trunks, or stumps of some old trees, which had been cut over for grafting on; but he has not made any use of it, further, than upon stumps, which have been deprived of the *benefit* of the *winds* to shake down the sap! It would appear, from his expressing surprise, that he thought it accidental: but it will be found to be a general rule and universal law of nature.

It appears he had no idea of it either preserving the bearing branches healthy, or causing the trunk and large branches to send out new wood to bear fruit, nor even of destroying the vermin; he says, " In middle aged trees,

of very old kinds, a succession of young shoots is annually produced by the vigour of the stock, and destroyed again in the succeeding winter *." This is certainly true, and has been observed by every body; but in trees which have been properly peeled, and especially where the capillary roots have been cut away, as mentioned in the physiology, I have not found one of these young shoots in a hundred, destroyed in the succeeding winter; but the very top bud, growing in the succeeding spring, and bearing fruit the following year.

I had none of these varieties, the moil, red streak, or golden pippin, mentioned by Mr Knight, to make trial on; but some kinds, the nonsuch, hawthornden, &c., which have long been in cultivation, and certainly far gone in a state of decay, have been completely renovated by the operation; and I can see no reason why it should not succeed on other varieties. To preserve the tree healthy, Mr Knight recommends cutting off the branches every third or fourth year, and never allowing

* See Knight's Treatise on the Culture of the Apple, p. 9, third edition.

it to produce either *fruit* or *blossom:* but, if he had peeled his trees, he would have found that this would not have prevented the tree from producing either blossom or fruit; for these young shoots, that come out in consequence of the peeling, commonly produce both blossom and fruit, the third, and sometimes the second year.

It appears from Mr Knight's observations, that the time seedling apple trees arrive at maturity, to produce fruit, is various, generally from nine to sixteen years; that grafted trees generally produce their first blossom in the same season with the original tree, from which the grafts are taken.

These rules will not apply in case of peeling and annular barking; for, by these means, either the original, or grafted tree, or even a single branch of either may be thrown into a bearing state several years before the other: and we have no doubt but the same means will produce the same effect upon the seedling plant; but of this I have no experience, having no seedling plants in my possession; and

we have reason to presume, that they will have similar effects on other species of trees.

This method of preserving trees healthy, by cutting them over, can be of no service, according to Mr Knight's own opinion, in preserving the old varieties; for he says, "that all plants of this species, *however propagated* from the same stock, partake in some degree of the same life, and will attend the progress of that life, in the habits of its youth, its maturity, and *decay*." By this, then, we are to believe, that when the original tree dies, all its offspring, *however propagated*, will die also. We have not experience to *speak* fully on this subject, but cannot help *thinking*, that it looks a little witchcraft like, and brings us in mind of stories told by some of our Scotch historians, of witches making figures in wax, of persons they wished to torment and kill, and roasting the figure at the fire; as the wax melted, the person wasted away and died.

The original pear tree, known by the name of the green pear of the yair, died several years ago, at that place, from which it had its name; but many thousand plants of its offspring

are still alive and healthy. The original apple tree, called Hawthornden, is still alive at that place and healthy; but many of its offspring are dead, and of what remain, very few are healthy. We are convinced, however, from observation, that *grafts* taken from a diseased tree, frequently carry the disease along with them; but we cannot say *always*; and we do not find in the animal, even hereditary and infectious diseases of the parent, *always* descend to the offspring; but, in both cases, it is certainly best and safest to choose a healthy parent.

Annular barking, or cutting out rings of the bark, has already been taken notice of in the physiology, but requires some further observations in practice.

This operation is performed with best effect and most safety, in the months of April and May. If it is done much earlier, before the sap flows vigorously, the cut edges of the bark will contract upon the wood, stop the flow of the sap, and kill the tree or branch: if much later, there will not be time to form a new bark. In pear, apple, cherry, and plumb trees, the ring may be from one-fourth to one-half inch broad,

taken out completely to the wood, and rolled immediately up pretty tight, with a piece of rag three or four rounds: woollen rag is preferable, because it is elastic, and yields to the growth of the tree.

The effect of this operation, appears quite astonishing, but is easily understood on the principles we have laid down. If the branch on which it is performed, is already in a bearing state, it will more certainly secure the crop for the same season; the fruit will be larger, of finer flavour, and sooner ripe; and the wood increased. If the branch is not in a bearing state, it will throw it into a bearing state next season, with all these advantages 99 times in 100. Though this operation on any part of the branch, produces these effects, the nearer the bearing part it is done, the effect is both greater, and more certain.

The ring is commonly filled up with new bark in four or five weeks, sometimes sooner, but no transverse bark.

The practice of annular barking, like that of peeling, is yet in its infancy; the extent,

therefore, to which it ought to be carried, and the advantages to be derived from it are not all known. There can be little doubt, however, that it will require to be carried farther in some species of trees, than in others. From some circumstances that have occurred accidentally, I have reason to think, that on some kinds which are very shy bearers, as the finer sort of French pears, it will require to be carried to much greater extent, and even part of the wood cut out to make them bear fruit; but I have not had time, from the experiments I have made, to speak further on this subject.

When a tree is killed by annular barking, which may very readily be done,—by performing the operation too late in the season, by leaving the ring uncovered, or by doing it below all the branches, leaves, and buds,—the part below the ring dies first. This further shews us, that the influence of the atmosphere is conveyed to the root, chiefly between the wood and bark: indeed it would almost tempt us to believe that it was conveyed wholly through this channel.

When a ring of bark is cut out and covered, the part above not only increases more than the part below, but increases more than it would have done, if the ring had not been cut off.

The part below the ring, which is above all the lateral branches, leaves, and buds, not only increases less than above, but increases none at all, till the ring is filled up with new bark: this shews that the formation of wood is produced by the action of the atmosphere alone; that, although the *sap* arising from the earth contain the whole matter, it would remain *sap*, and no more, for ever, were it not for the influence of the atmosphere:—so we conceive that although the egg contain the whole matter, it would remain an egg for ever, were it not for the influence of the hen. In short, we look upon the sap as the materials, the atmosphere the agent, chemist, or workman.

On the above principle it is easy to account for the barrenness and canker of fruit trees; suppose a tree drawing ten pounds of sap from the earth, and that the powers of the atmo-

sphere are capable to convert these ten pouuds, but no more, into fruit; suppose then, that instead of ten, the tree drawing fifteen pounds, I say not one ounce will be converted into fruit, because the powers of the atmosphere are overcome, and that balance lost which is necessary for the production of *fruit* (14). Suppose, further, the tree drawing twenty pounds, I say not one ounce will be converted into either fruit or wood, but burst out and end in canker; because that balance, necessary for the preservation of health, is lost (9). In like manner, suppose a man's stomach capable to digest one pound of meat, and no more: if he eat one pound, it will go to nourish and increase his body; but if he eat two pounds, the powers of digestion being overcome, not a *single grain* will go to the nourishment of his body, but on the contrary, induce disease, and derange the whole system.

It is to be observed, however, that canker, to a certain extent, on a tree or branch, frequently throws it into a bearing state; but this is on the same principle with annular barking, by cutting off a great part of the sap arising from the earth.

We have laid down principles from the universal laws of nature,—from these principles we have deduced general rules,—we have applied these rules to practice, and found them answer to our most sanguine expectations:—specific rules will be acquired by experience. We hope the subject will be followed out by men of more experience, and greater abilities, and lead to discoveries beneficial to mankind.

FINIS.

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